Workshop on future needs for regional air pollution strategies

Saltsjöbaden 10-12 April 2000

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Organised by
The Swedish ASTA Programme and
The Nordic Council of Ministers

in collaboration with
the UN ECE Convention on Long Range Transboundary
Air Pollution and
the European Commission DG Environment

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The Nordic Council of Ministers
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The Nordic Council
was formed in 1952 to promote cooperation between the parliaments and governments of Denmark, Iceland, Norway and Sweden. Finland joined in 1955. At the sessions held by the Council, representatives from the Faroe Islands and Greenland form part of the Danish delegation, while Åland is represented on the Finnish delegation. The Council consists of 87 elected members - all of whom are members of parliament. The Nordic Council takes initiatives, acts in a consultative capacity and monitors cooperation measures. The Council operates via its institutions: the Plenary Assembly, the Presidium and standing committees.

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Föreliggande rapport utgör en sammanställning av presentationer och resultat från en workshop om framtida vetenskapliga och politiska behov inom området gränsöverskridande luftföroreningar i Europa och Nordamerika. Den anordnades i Saltsjöbaden 10-12 april 2000 i samarbete med Konventionen för långväga gränsöverskridande luftföroreningar (CLRTAP) och EU-kommissionens miljödirektorat. Workshopen genomfördes i perspektivet av det nyligen påskrivna protokollet om begränsning av emissionerna svaveldioxid, kväveoxider, flyktiga organiska ämnen (VOCs) och ammoniak (Göteborgsprotokollet, December 1999). Representanter från de flesta organ under CLRTAP deltog. EU och WMO var också representerade.

Workshopen omfattade muntliga presentationer, grupp- och plenardiskussioner och resulterade i ett antal slutsatser och rekommendationer. Workshopens allmäna slutsatser är tillsammans med slutsatserna från de individuella grupperna, referat av presentationerna och övrigt skriftligt material, sammanställda i denna rapport.

Workshopen organiserades av en kommitté som också svarade för den slutliga sammaställningen av slutsatser och rekommendationer. Kommittén bestod av:

Markus Amann, IIASA, Österrike
Keith Bull, UN ECEs sekretariat
Anton Eliassen, Norges Meteorologiska Institut, Norge
Peringe Grennfelt, IVL, Sverige
Ramon Guardans, CIEMAT, Spanien
William Harnett, US Environmental Protection Agency, USA
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Rob Maas, RIVM, Nederländerna
Martin Williams, Department of Environment, Transport and Regions, Storbritannien

De praktiska arrangemangen handlades av Peringe Grennfelt och Catarina Sternhufvud, IVL, och Lars Lindau, Naturvårdsverket.

Workshopen finansierades av det svenska forskningsprogrammet ASTA (International and National Abatement Strategies on Transboundary Air Pollution) och Nordiska Minsiterrådet (NMR).

Preface

This report compiles the outcome of a workshop on future scientific and policy needs within the area of transboundary air pollution in Europe and North America. The workshop was held in Saltsjöbaden 10-12 April 2000 and organised in collaboration with the UN ECE Convention on Long Range Transboundary Air Pollution and the European Commission DG Environment. The workshop was held in the view of the recently signed protocol for the control of sulphur dioxide, nitrogen oxides, volatile organic compounds (VOCs) and ammonia (Gothenburg Protocol, December 1999). Representatives of most subsidy bodies of the UN ECE CLRTAP were participating. The European Union and WMO were also represented.

The workshop included oral presentations, group and plenary discussions to agree upon conclusions and recommendations. The general conclusions of the workshop are together with the conclusions of the individual groups, abstracts of the presentations and other written material, included in this report.

An organising committee was established for the planning of the workshop and for the final preparation of the conclusions and recommendations. The committee consisted of:

Markus Amann, International Institute for Applied Systems Analysis, Austria
Keith Bull, UN ECE Secretariat
Anton Eliassen, The Norwegian Meteorological Institute, Norway
Peringe Grennfelt, Swedish Environmental Research Institute, Sweden
Ramon Guardans, CIEMAT, Spain
William Harnett, US Environmental Protection Agency, United States
Lars Lindau, Swedish Environmental Agency, Sweden
Martin Lutz, European Commission DG Environment
Rob Maas, RIVM, The Netherlands
Martin Williams, Department of Environment, Transport and Regions, UK.

The practical arrangements were handled by Peringe Grennfelt and Catarina Sternhufvud, Swedish Environmental Research Institute, and Lars Lindau, Swedish Environmental Protection Agency.

The workshop was supported by the Swedish ASTA research program (International and National Abatement Strategies on Transboundary Air Pollution) and the Nordic Council of Ministers (NMR).

1. Introduction

1.1 General

This report summarises the results of a workshop on Future Needs for Regional Air Pollution Strategies held in Saltsjobaden (Sweden) on 10-12 April 2000. The workshop was organised by the Swedish ASTA Research Programme and the Nordic Council of Ministers in collaboration with the Executive Body of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and the European Commission DG Environment (DG ENV). More than 100 experts from 21 countries, UN ECE secretariat, European Commission (EC), European Environment Agency (EEA), World Meteorological Organisation (WMO) and environmental and industrial non-governmental organisations (NGOs) participated in the workshop.

The workshop focused on regional environmental and health problems related to emissions of sulphur dioxide, nitrogen oxides, volatile organic compounds (VOCs) and ammonia. It was held to identify the future measures needed after the recently signed Gothenburg Protocol and the proposal for an EU National Emission Ceilings Directive. These agreements will reduce the emissions in Europe substantially. However, additional extensive control measures are necessary in order to reach the environmental goals in terms of critical loads etc. in all Europe. It is expected that revisions of the Gothenburg protocol as well as the EU directive will take place in about 5 years time. The next few years will therefore offer the possibility for improvement of the scientific knowledge in order to support future policy work. This is also the aim of the Clean Air for Europe (CAFE) programme of the European Commission which is planned to commence early in 2001.

The discussions were also held in the light of other ongoing international activities in Europe as well in North America and on a wider scale, e.g. Arctic Monitoring and Assessment Programme (AMAP) and the Framework Convention Climate on Climate Change (FCCC). In addition, it was recognised that future activities would need to address increased concerns on health effects from particulate matter. Further it was recognised that transboundary air pollution problems related to heavy metals and persistent organic pollutants (POPs) are also of great importance for the CLRTAP. These were recently considered at a workshop organised by EMEP, WMO and UNEP (Geneva 16-18 November 1999).

1.2 Aim of the workshop

The aim of the workshop was to outline the basis for development of regional air pollution strategies in Europe taking into account the needs and developments in North America and elsewhere. The themes discussed were:

- Driving forces for air pollution control for the coming 5-15 years
- Advantages and disadvantages of the present concepts and achievements
- Alternative concepts and methods
- Other policy actions influencing the regional air pollution strategies
- Scientific needs and further collaboration on scientific research and development.

2. Conclusions and Recommendations

1. Driving forces

Environmental aspects:

The impact of regional air pollution on human health, quality of life and the environment is an environmental problem likely to remain of great concern in the coming years.

Human health is considered to be a main driving force, especially with respect to the effects from particulate matter. Tropospheric ozone will also be an important driving force for regional air pollution control.

The threats to ecosystem biodiversity and productivity by acidification, eutrophication and airborne toxic compounds will remain even after 2010 and will need further attention.

Effects on materials and cultural heritage as well as to marine ecosystems should be considered in future strategies.

Local air pollution problems are expected to be part of future regional air pollution control strategies; they will strengthen the control needs, taking into account the transboundary component of local air pollution.

Control strategies for greenhouse gases will be of great importance for the development of control measures for regional air pollution.

Institutional aspects:

Increasing European integration and harmonisation will be an important driving force leading to stronger incentives for emission control, especially in the EU accession countries and improved collaboration after the enlargement of the EU.

The involvement of stakeholders (those with vested interests) and public awareness in each country and in the in the processes under the UNECE Convention and the EU are important and will improve interest and motivation for emission controls. In this connection it is important to clearly identify and visualise the observed and expected benefits of the control measures and the existing agreements.

2. Concepts and methods

It was agreed that the successful effect-based (critical loads etc.) concepts used in the Gothenburg Protocol will be an effective tool even for future strategies. However, it was recognised that it needs further development in order to fit to the new environmental situations and control requirements and taking into account new scientific and technological developments.

The concepts have to be further developed in particular with respect to:
- Quantification of costs and benefits of control measures;

- Methods that include non-technical measures;
- Structural and technical changes expected to take place during the next 10-15 years;
- The establishment of linkages between different scales: local, regional and global;
- Links between international and national policies;
- Monitoring of implementation and compliance.

Any further development has to consider the increasing environmental awareness and legislation within the sectors both at national and international levels. In particular, new air pollution control approaches should consider:

- Liberalisation of electricity market;
- Future European agriculture policies;
- Incentives to solve congestion, noise and environmental problems within the transportation sector;
- Environmental management within industry;
- Climate change.

3. Science and data support

Basic science

An accepted effects-based regional air pollution strategy will always be based on, and limited by, a commonly shared platform of scientific knowledge. Therefore, high level basic research within all areas of importance is a crucial factor. Countries should be made aware of the overall decreasing support to scientific environmental research and ensure that the overall expertise will not be lost. Organisations/bodies providing some funding for international environmental research, e.g. EC DG Research, should be informed on the scientific needs for the future strategies. (Scientific collaboration is considered under the item on Collaboration.)

Among the wide variety of scientific needs, the following areas identified as being of particular importance (responsibilities of countries, subsidiary bodies of the Convention and other bodies are given in parentheses):

a) Scientific understanding on long range transport and effects of particulate matter (EMEP, EC, countries);
b) The intercontinental and hemispheric transport of atmospheric pollution (EMEP);
c) Development of environmental indicators (WGE);
d) Methods for the evaluation of effectiveness of policies including cost-benefit analysis (WGSR, TFIAM, WGE);
e) Methods for the assessment of risks to human health and the environment (WGE, EC);
f) Understanding and dynamic modelling of environmental changes (the nitrogen cycle, climate change) including the dynamics of environmental effects and recovery, especially at decreasing exposures and loads (WGE);
g) Understand crucial linkages between local, regional and global changes (EMEP, WGE);
h) Methods to monitor environmental changes (EMEP, WGE);
i) Develop and apply methods for uncertainty analysis and validation of the models, data and assumptions on which the strategies rely (WGE, EMEP, TFIAM).

Data

The collection of data on emissions, environmental concentrations, deposition, fluxes, effects and abatement costs is necessary for the evaluation of present control measures and for the development of future strategies. There is a large need for improvement in data collection and quality assurance within practically all areas. The workshop recognised in particular the importance of improvements with respect to following (responsibilities of countries, subsidiary bodies of the Convention and other bodies are given in parentheses):

a) Emissions and atmospheric data (countries);
b) Effects data: the need for data on environmental status, ecosystem damage and health effects inventories were particularly mentioned (countries);
c) Economic and technical data (countries);
d) Data accessibility, understanding, comparability, transparency, quality assurance (EMEP, WGE, countries);
e) Avoid duplication of reporting obligations (EMEP, WGE, TFIAM, Implementation Committee, EB, EC, EEA bodies).

Integrated assessment modelling

The role of integrated assessment modelling will remain crucial in the future and models need to be developed for scenarios on cost-effective reductions and for determination of optimised strategies. The following areas were considered to be of particular importance:

a) The development of techniques for handling several environmental targets simultaneously (TFIAM);
b) The development of optimisation techniques that include primary and secondary particulate matter (TFIAM);
c) The improvement of techniques for robustness and uncertainty management (TFIAM);
d) The development of supplementary models, e.g. sector scenarios, evaluation, uncertainties etc. (TFIAM);
e) The development of interfaces to cover urban scale. (TFIAM).

General issues

A number of general issues were discussed but the following were noted as being in particular need of attention:

a) The development of methods for helping countries to implement their international agreements; the Convention’s scientific co-ordinating centres have data and models that can support countries in their national implementation of the international agreements (EMEP, WGE, TFIAM);
b) The need to improve scientific collaboration between countries; the future scientific support will mainly be based on national programs and projects and the decreased funding for regional air pollution research will result in the need for in depth collaboration (countries);
c) The communication of the scientific results should be improved with respect to policy and the public (all bodies).

Recommendations on workshops

In order to discuss and improve the scientific basis of future work under the Convention the following expert workshops or meetings were identified:

a) Workshop on health indicators (WGE);
b) Expert meeting on hemispheric/regional modelling (EMEP);
c) Expert meeting on organic particulates (EMEP);
d) Workshop on (alternative) methods to calculate costs (especially structural changes), update discount rates etc. (WGSR, TFIAM).

4. Collaboration

The workshop stressed the importance for continued in international collaboration and recommended that there should be:

a) Improved co-operation in science, in development of tools and in collection of data between the European Commission and CLRTAP; collaboration should in particular be enhanced between the subsidiary bodies under the Convention and the European Commission, including EEA, in the framework of the Clean Air For Europe (CAFE) programme (all bodies under CLRTAP);
b) Improved links to global international bodies of importance e.g. IMO and ICAO (all bodies under CLRTAP, the CLRTAP secretariat);
c) Joint European - North American activities established, e.g. on hemispheric transport of air pollution and the effects on human health, ecosystems and on risks of these pollutants (WGE, EMEP, TFIAM);
d) A European research programme on regional air pollution effects established (similar to that of EUROTRAC) (WGE, EB);
e) Increased collaboration with other regional and pan-European Conventions; it is of particular importance to attract those regions and conventions, that are not at present participating/collaborating to the fullest extent (e.g. the Barcelona Convention) (WGE, EB, EMEP, the CLRTAP secretariat);
f) A sharing of the experience from the work within CLRTAP and EU regional air pollution strategies with other organisations aiming at developing strategies, e.g. the European Commission's Auto-oil initiative, those concerned with urban modelling and the Framework Convention on Climate Change (FCCC); it was suggested a "tool box" was required (EB, EMEP, TFIAM, WGSR);
g) Continued close co-operation between CLRTAP's subsidiary bodies and WHO and WMO (EMEP, WGE);
h) Improved harmonisation of reporting requirements and compliance monitoring between CLRTAP, the European Commission and FCCC (EB, EMEP, WGE, European Commission, EEA);
i) Improved communication and interaction with industry, environmental NGOs, policy makers and the public with regard to the implementation and development of future regional air pollution strategies; A strategy for communication should be developed (all bodies under the Convention).

5. Future strategies and immediate actions

In order to prepare for the future negotiations a number of more policy-related issues were discussed and the following actions were recommended (with responsibilities within parentheses):

a) Promote ratification - problems vary between countries but it was noted that poor progress had been made on recent Protocols; there is a need for policy awareness to increase pressure (EB);
b) Transfer the CLRTAP experience to other areas and UN regions (CLRTAP secretariat and countries);
c) Establish scientific review panels of present strategies in order to form a basis for the development of the future concepts and strategies (EB);
d) Enhance linkages between urban and transboundary issues (regional and global) at the scientific/information level in the first instance, in order to quantify source contributions on all scales (EMEP, WGE, EC, countries);
e) Promote linkages between urban, transboundary and hemispheric issues in co-operation with the CAFÉ program (EMEP, EC, countries);
f) Review new information and data on the impact of air pollutants (especially particulate matter) on human health (WHO, WGE, EC);
g) Incorporate dynamic tools to predict environmental changes resulting from future emission scenarios (WGE, TFIAM);
h) Base protocol revisions upon integrated assessment models including, for example, dynamic description of effects, particulates, level II approach for ozone, linkages between urban and regional air quality (EMEP, WGSR, TFIAM);
i) Develop risk assessments and abatement policies for heavy metals and persistent organic pollutants of significance to human health and environment (WGE, EC);
j) Create an Internet-based bulletin for meetings and reports (CLRTAP secretariat).

3. Working Group Reports

3.1 WG 1: One Clean Air Programme - local, regional and global issues under the same strategy

Chair	Martin Williams	Rapporteur	Max Posch
Participants	Svante Bodin Anton Eliassen Dieter Jost		Per B Suhr Dick Van den Hout Eli Marie Åsen

One Clean Air Programme possible at scientific level

- local: urban vs. rural (e.g. ozone);
- global: background concentrations

Local and global issues not in the remit of the Convention

Prerequisites for a pan-European strategy to develop new protocols (which are also ratified!):
- pan-European problem(s)
- pan-European goals with same/similar prioritisation.

..... not really given, but:
If Convention. moves from "law-making" to co-operative framework (on air pollution problems), then a strategy possible.

1. Driving forces

Different countries have different problems, but transboundary problems (pollution, traffic) can/should bring them together

- Issues: PM, ozone, (global change)

- Take advantage of drive for EU-harmonization
- Take advantage of work/incentives of EU accession countries
- Involve stakeholders (NGOs) more in the Conv. process
- To get (better) involvement of countries, get involvement (from start) of scientists in those countries

Role of effect-based strategy (vs. BAT, precautionary principle):
- effects-based strategies desirable

Role of Convention:
- Cooperative framework
- Bridge North America - Europe - Russia (CIS)
- As an example (e.g. EU acidification strategy)

2. Concepts and methods

Critical loads, AQGs etc:
- don´t throw away things that worked, but
- take onboard/adapt to new developments
- critical loads/levels:
  - simplicity appealing, but desirable:
  - better link to damage,
  - extension from threshold to damage function
  - account for recovery (through dynamic modelling)

Implementation:
- Monitoring should be steered towards compliance
- Reporting procedures should be harmonised (with EU etc)

Cost effectiveness:
- laudable goal, but not (fully) realised by finally deviating from cost-effective scenarios

Benefits:
- Quantification and monetarization desirable, but notoriously difficult (esp. for ecosystems)

Sustainable development:
- Convention has an important role to play to develop sustainable development indicators (e.g. CLs)

Sectors (traffic etc):
- Non-technical/structural sectoral measures should be included in Conv. work (IAM)

Funding etc.:
- Widening gap between EU-accession countries and other non-EU countries concerning financial and other support is of concern

3. Science

- WGs/EMEP important interface between science and policy

- EU could/should play bigger role in support of this interface

- More involvement from (all) countries needed in this interface

Science needed:
(a) appraisal of state of ecosystems (e.g. with respect to acidification)
(b) PM: source-apportionment, organic PMs
  - Conv. could benefit from and contribute to revision (in 2003) of EU "Particle Directive"
(c) Ozone: hemispheric (US-Europe WS) and local issues, NOx vs. VOC control

... Convention works at cutting edge of science/knowledge.

Integrated Assessment:
- Priorities:
  - link between urban and regional scale needed.
  - more transparency in scenario building
  - inclusion of passive measures (energy saving, restructuring of energy system)
- Transparency:
  - First steps and plans of EMEP, IIASA (CIAM) and CCE welcomed and necessary
- QA (data pedigree) and communication should be improved.

4. Collaboration and outreach

- include marine environment in review (concerning eutrophication) ... collaboration with HELCOM, OSPARCOM

-TFMM/WMO connection should be (further) developed (chance of better involvement of other countries)

- Commonly shared (emission) databases would be of great value and save resources (avoid duplication) ... but institutional barriers have to be overcome

- Monitoring networks and reporting should be integrated as far as possible

- LRTAP Conv. example in several areas for similar bodies ... share experience

5. Future

- Urge to (sign and) ratify Protocols.

- "We did as well as we could"

- Improvements are (always) possible:
  - PM (as far as S, N and VOC are concerned)
  - Kyoto-compatible (energy) scenarios
  - improved CL(-methodology)

- "Satisfied" with benefits, otherwise no signature

- Why was damage to materials not included?

6. The process

Cross-institutional information infrastructure and WGs between UN/ECE (which includes N.A.!) and EU should be established based on a catalogue of common work (example: PM), ultimately leading to a common strategy.

Technical bodies under Conv. (EMEP, TFs, ICPs) could also serve EU-WGs (approval of non-EU countries needed!)

3.2 WG 2: Sector Integration

Chair	Bill Harnett	Rapporteur	Beat Achermann
Participants	Oystein Aadnevik Jean-Guy Bartaire Jean-Philippe Bouton David Corregidor Ulrich Dämmgren Alec Estlander Melanija Lesnjak		Lars Lindau Stine Lombnaes John Murlis Lars Nordberg Sandrine Nunge Berndt Schärer Tomas Verheye

1. Driving forces

What are likely to be the driving forces for air pollution control in Europe and North America over the next 5-15 years?

The Working Group identified several possible driving forces for future air pollution control policies. The priorities in these driving forces might be different from country to country depending on the environmental policy already carried out in the past, the social and economic situation, the domestic versus the international framework etc..

The following driving forces were identified without reflecting a strict priority ranking:

- Human health (e.g. particulate matter (PM) and ozone as common interests of North America and Europe);
- Quality of life considerations (including but not limited to human health and the environment);
- Public understanding of problem matters/ Public awareness;
- Climate change (high on political agenda);
- Biodiversity (e.g. links with eutrophication, acidification and ozone);
- Industries take positive independent action for improved public image (Environmental Management Systems);
- Particulate matter (PM), ozone, eutrophication and acidification remain primary drivers with PM moving up the agenda;
- Non-air pollution drivers which might result in emission reductions: e.g. noise, traffic congestion etc.;
- National priorities tend to be based on local problems or hot spots: it is important to integrate such problems into regional or global strategies;
- International pressure as driver for national action.

2. Concept and methods

Will present concepts and methods used for air pollution strategies and policies in Europe and North America be appropriate in the future?

The Working Group strongly felt that the effects based approach is the right approach and that a move back to arbitrary targets would be very undesirable.

But there is still a long way to go on the effects based path and several items were identified which could be further developed or strengthened:

- Need for improved substantiation of effects on human health and sensitive ecosystems, including possible recovery due to air pollution control;
- More efforts in carrying out cost and benefit assessments. This will get more and more important the nearer we get to environmental targets. More emphasis has to be given to the time dynamics of costs. Benefit assessment needs to include effects on cultural heritage, forests and semi-natural ecosystems as well as quality of life (might be hard to quantify but worth while doing);
- Economic instruments need more attention in the next protocols;
- Public and other stakeholders should be closer involved in the work of the Convention to get a better feeling about the right questions to answer;
- "Equal share of pain" concept, competitive equity (e.g. best available techniques BAT).

3. Science

What scientific knowledge, data and models are available (or might become available) to aid policy development for international and national policy bodies in Europe and North America?

The Working Group identified the need to continue to use science in a pragmatic way in order to retain a manageable tool as it was the case in the past with the different elements contributing to integrated assessment modelling. A very complex and sophisticated approach, which could be managed only by few parties, would not be helpful.

The following elements were considered to be essential for a manageable tool and could be further developed in the near future:

- Links between sources of air pollutants and receptors;
- Understanding of atmospheric processes (particularly ozone and PM formation);
- Emission inventories;
- Cost and benefit data;
- Optimisation techniques for handling different targets simultaneously.

The Working Group also expressed its views with respect to the following elements which need further scientific input:

- Spatial resolution of models: The 50x50 km^2 EMEP-approach is satisfactory, but in addition a smaller scale resolution is needed for risk assessment at the level of sensitive receptors;
- Environmental indicators are needed to demonstrate effects. Such indicators should be meaningful for the communication to the public and to politicians.;
- Integration of anticipated climate change policy into the assessment of impacts of existing and future protocols (e.g. impact of climate change on acidification and nitrogen cycle etc.);
- Additional models to supplement the current integrated assessment analysis and to increase the understanding of multi-target optimisation and its uncertainties;

- Need for significant information on particulate matter PM (e.g. emissions, size distribution, composition, source receptor analysis etc.);
- Access to science and data for the public and for stakeholders can be improved (e.g. Internet use for dissemination of data, e.g. from Working Group on Effects and EMEP activities).

4. Collaboration and outreach

How can more effective scientific and policy collaboration between countries and other bodies be improved?

The LRTAP Convention was considered to be a very good example of efficient international co-operation and this experience could be shared with other organisations. In addition to the organisations and Conventions mentioned in the list of questions to the Working Groups, the following international organisations were identified to play a potential role in further co-operation: OECD, ICAO, WMO, WTO, Mediterranean Action Programme (under Barcelona Convention). It was felt that there is in general a broad willingness to co-operate and to share experiences, but all organisations have tight time schedules and limited resources, which might be a reason that we may not always be able to engage their interest.

Several possibilities to increase the efficiency of co-operation, but also constraints were mentioned:

- Joint workshops with other organisations;
- Strengthen the communication with EU: common use of databases, elimination of potential duplication;
- Engagement of agricultural sector: important but difficult. Better links needed between environmental and agricultural agencies;
- Outreach: the links between the work under the Convention and the needs of the civil society can be further developed;
- Need to be realistic and practical about availability of resources to support the dialogue.

5. Future strategies

What might a revised Gothenburg Protocol (and Arhus Protocols) look like and what strategy do we adopt to get there?

Since the public is interested in a better environment and in an increase in quality of life, the emphasis should remain on the effects based approach.

An effects based approach not only requires a further development of effects science and of technical and modelling tools, but also a translation of negotiated and achieved emission reductions to environmental benefits. There is a need to have meaningful indicators to track the progress and the accomplishment of the goals. All stages in further work and in implementation need to be communicated to involved stakeholders and to the public (visualisation of achievements).

A „common umbrella“ for a future strategy could also be the sustainable development; it could be used as a general framework, but by itself it was considered to be too general and there would be a need to fill it with content from the umbrella down to single sectors.

The question has to be addressed how to accommodate in the future different priorities/goals existing in North America and Europe (health vs. environment, standards). A potential issue is that environmental goals of countries are not harmonised. This could be more relevant as we get closer to targets.

A common interest of North America and Europe could be the use of PM as a driving force for the revision of the „multi-pollutant/multi-effect“ protocol (Gothenburg Protocol). Such an approach could address the problem of primary particles as well as - over the secondary aerosols - all air pollutants already covered by the Gothenburg protocol.

Potential synergies might be explored by linking the work under the Convention with work carried out in other fora, e.g. climate change.

A greater need for involving economic instruments was identified because problems are expected to become more difficult to be solved by simply applying best available techniques (BAT). In addition there will be a need to look beyond economic efficiency towards social equity in strategies.

With respect to implementation of existing protocols (e.g. Aarhus protocols), the

problem of few ratifications was noted. Obviously there is no single reason for the disappointing progress on POPs and HMs; the problems vary between countries. Building public awareness might increase the pressure for ratification.

6. Sector integration

Working Group 2 was asked to discuss the problem of sector integration and to try to elaborate ideas of how a sector integration could be handled under the LRTAP Convention.

The Working Group identified the following sectors to be addressed: energy, industry, transport, agriculture, residential/commercial.

Integration could be defined in different ways:

1. Integration of environmental policy into single sectors.
2. Integration of control of emissions from sectors into an overall effect based and cost-effective policy to achieve specific Air Quality and environmental goals.

For the discussion within the Working Group the second option was used.

The realisation of the second option requires a tool like „Integrated Assessment Modelling“ (IAM), which was already used for the elaboration of the Gothenburg protocol. The Working Group felt that there is no need to have major changes in IAMs. The Convention should continue in this way but add the integration of anticipated climate change policy coupled with sensitivity analysis.

The basic approach of IAM can be kept, but there is a need to have better input data at the national level:

- Emission inventories;
- Cost figures;
- Data on structural changes (including shifts in energy policies);
- Aggregation/disaggregation of data.

The LRTAP Convention needs to set a workplan with time schedule to allow technical experts to determine what progress can be made on the above mentioned elements to assist in further protocol revisions.

3.3 WG 3: Scientific Knowledge

Chair	Harald Sverdrup	Rapporteur	Michael Woodfield
Participants	Richard Derwant Guy Fenech Martin Forsius Hans-Christen Hansson Berit Kvaeven Lars Lundin Gina Mills Shailendra Mudgal Göran Nordlund		Josef Pacyna Håkan Staaf Sanna Syri Juha-Pekka Tuovinen Merete Ulstein Johannessen Rolaf Van Leeuwen Gianni Vialetto Sahari Zlatev

Summary

1) The scientific knowledge we have, or are developing, results from:

a) assessing the benefits to be achieved from protocols

b) implementing agreements under existing protocols

c) planning for and anticipating future regulation.

2) In the course of describing the benefits expected from existing protocols scientific knowledge has been amassed on emission reductions, deposition and transport characteristics and ecosystem response. Typically scientific work has concentrated on emission inventory development, data base building, ecosystem assessment, measurement and modelling etc. Work is generally managed at a national level and, while more should and could be done, reasonable progress is being made.

3) In order to test compliance with existing protocol requirements scientific knowledge collected at national level has to be considered at a regional level. There is a need to review the adequacy of emission reduction, assess to information, evaluate tools used in validate report information. Our knowledge of this level is not well developed. This integration work needs to be managed at an ECE or regional level.

4) To meet the challenges and expectations of future regulation we need scientific knowledge and tools able to predict risk, identify options and quantify potential benefits. Such knowledge could come from an improved cost-benefit analysis capability, predictive tools, dynamic models etc. The challenges stem from the interaction of global phenomena with regional and local problems. The impact of well understood pollutants and newly recognised environmental contaminants on human health is likely to be important. Work in this area needs to be managed and co-ordinated at an international level via the close collaboration/integration of national programmes into co-operative ventures.

1. Driving forces

The scientific knowledge we have, or are developing, results from:

a) describing the benefits to be achieved from protocols i.e. existing commitments

b) testing the implementation of agreements under existing protocols

c) anticipating the challenges of the future i.e. new protocols and agreements.

Commitments under existing protocols continue to act as effective drivers of the scientific programmes of signatories, particularly to: assess and report emissions, monitor ambient air and precipitation, monitor ecosystem impacts, develop modelling and assessment tools.

Concerns at the cost, together with questions regarding the effectiveness, of the measures and actions in place at national level are acting as drivers for signatories to work together to develop harmonised methods of independently testing and enforcing the compliance of commitments. This is driving the development of new scientific tools, transparency, and a greater alignment of scientific effort at regional level.

There is a growing awareness of the influence of global scale pollution on what had hitherto been considered local and regional scale problems. Similarly it is clear that multimedia cross influence can not be treated lightly. In addition concerns over local scale, particularly health related, phenomena are becoming increasingly important. Together these issues are beginning to drive the development of more 'broad band/integrated' scientific models which in turn demand more sophisticated input data and monitoring information suitable for 'fine tuning' and validation.

2. Concepts and methods

From the 'scientific knowledge' point of view the concepts and methods developed to meet the historical needs of quantifying the costs and benefits of protocols have had the time and resources needed to develop functional systems which are now delivering useful data and information. Problems, where they exist, relate most to the unforeseen complexity of the tasks undertaken and the labour/resource requirement of completing well defined tasks – on the whole they probably don't require the development of novel methods and concepts.

The majority of work completed to date has been carried out at national level where programme management is relatively straightforward. The challenges of understanding and realising the international benefits/synergy at a regional level are more difficult and the necessary working concepts and methods are much less well developed and agreed. Progress at regional scale requires greater collaborative activity which is co-ordinated and managed at regional level.

The understanding of the wider threats posed by the combined impact of both global and local pollution is developing slowly and the concepts and tools are relatively poorly defined, the means of co-ordinating and managing such activities are still rudimentary.

3. Science

Traditionally, under the LRTAP Convention, scientific work has concentrated on emission controls, data base building (inventories, technologies, effects etc), impact assessment, measurement/monitoring and modelling etc. In the course of assessing and describing the costs and benefits expected from existing protocols scientific knowledge has been amassed on emission reduction potential, deposition characteristics and ecosystem response. Despite considerable progress there is still a need to improve a number of areas of knowledge, for example: mapping of receptors, understanding of ozone impacts, materials damage, and completion of regional inventories and databases.

In order to test compliance with existing protocol requirements scientific knowledge collected at national level has to be evaluated at a regional level. There are programmes in place to review the adequacy of emission reductions, assessment information, and the evaluation of tools used to report information but our knowledge at this level is not well developed. In particular 'uncertainty' has to be better quantified and validation tools need to be developed and proved.

To meet the challenges and expectations of future protocols and agreements we will need scientific knowledge and tools better able to scale the pollution problems, predict risk, identify options and quantify potential benefits. Such knowledge could come from an improved cost-benefit analysis capability, predictive tools, dynamic models etc. The challenges stem from the interaction of both global (climate change and cycling of heavy metals and POPs) and local phenomena (health) with regional problems. The impacts of well understood pollutants and newly recognised environmental contaminants on human health are likely to be an important component. Particular interest is attached to the impact of fine particulate material, which can be considerable at all scales, however the health impacts of non-particulate material, such as brominated compounds for example, should not be neglected.

4. Collaboration and outreach

Work managed at a national level is proceeding and, while more should and could be done, reasonable progress is being made. These programmes, by their very nature, however are specific to the specific requirements of individual signatories.

Co-ordination of scientific knowledge at a regional level is not as well developed and the co-ordination of national programmes should to be encouraged. This integration work needs to be managed at an ECE or regional (European) level.

Joint activity at a global level is more difficult and needs to be managed and co-ordinated at an international level via the integration of national programmes into co-operative ventures. Greater co-operation of N American, Asian and European programmes should be encouraged.

5. Future strategies and processes

Greater use of the Technology Transfer and R&D provisions of existing Protocols should be used to promote the greater alignment of national programmes. More joint activity could be encouraged by regional organisations such as the ECE and the EU possibly using the EU 6^{th} Framework Programme. Activity within global fora, such as UNFCCC and OECD, could possibly be linked with inter-regional activity with the ECE and other UN regions i.e. ESCAP.

3.4 WG 4: Integration of Air Pollution Policies Between Europe and North America: Scientific Needs and Policy Possibilities

Chair	Richard Ballaman	Rapporteur	Alan Jenkins
Participants	John Beale Sergey Doutchak Heinz-Detlef Gregor		Terry Keating Martin Lutz John Miller

1. Driving forces

What are likely to be the driving forces for air pollution control in Europe and North America over the next 5-15 years?

Conclusions:
First of all, acid rain problems are not solved! We need to have a comprehensive review of the current status of the environment, including where we have come from and what problems remain. Secondly, particulate matter (PM) and ozone health effects will be the main policy drivers in both Europe and North America.

Recommendation:
PM should be a main focus of collaboration between North America and Europe.

2. Concepts and methods

Will present concepts and methods used for air pollution strategies and policies in Europe and North America be appropriate for the future ?

Conclusions:
Rapid developments are occurring in our understanding of PM at all spatial scales. There is a lot of work going on in both Europe and North America.

Recommendation:
Europe should take an active role in co-operating with North America, recognising that considerable work is already underway in North America on PM.

3. Science.

What scientific knowledge, data and models are available [or might become available] to aid policy development for international and national policy bodies in Europe and North America.

I. Hemispheric Modelling

Conclusions:

Recommendations on scientific policy and strategy in the field of Heavy Metals and POP pollution were developed by the WMO/EMEP/UNEP Workshop on modelling of atmospheric transport and deposition of POPs and Heavy Metals (Geneva, 16-18 November 1999).
As stated in Article 8 of the Gothenburg Protocol, there is a clear need to understand the hemispheric transport of photooxidants and their precursors, as well as aerosols, heavy

metals, and POPs. There is a clear need for co-operation between North American and European scientists.

Recommendations:

1. Organise a European-North American workshop on hemispheric transport of photooxidants and aerosols.
2. Not another science meeting, but a meeting to promote communication between the LRTAP policy community and appropriate scientific communities with the goal of identifying short and long term objectives for joint research.
   Questions to be addressed:
   - What do we know about intercontinental transport of oxidants and other pollutants affected by CLRTAP?
   - What is the global distribution of oxidants and aerosols?
   - What are the observed trends? What are the anticipated future trends?
   - What are important processes affecting transport?
   - In the short term (2-3 years), what questions can be addressed given existing tools and databases?
   - What questions should be addressed as part of a long term research program under the Convention?
   - What can different organisations (eg., WHO, EUROTRAC, WMO, …) contribute?
3. Recognize the connections between process that are important for the modelling and monitoring of hemispheric transport of photooxidants, aerosols, Heavy Metals, and POPs.
4. EMEP and other LRTAP bodies should seek opportunities to support the work of EANet, especially through the WMO.

II. Assessment of Effects on Ecosystems

Conclusions:

- Scientific co-operation between North America and Europe on effects on ecosystems was good by the past but needs improvement for the future.
- We need to improve methods for effects-based approaches, especially for Heavy Metals and POPs.
- We need to improve methods for quantifying the economic costs and benefits related to ecosystem impacts.
- We need to have more emphasis on dynamic models, especially for prognosis and with respect to estimating the time-scale of recovery.

Recommendations:

Collaboration between North America and Europe on a scientific level, especially in the ICPs, should be formalized under the WGE. A coordinated report of the current status of the environment and the impact of the LRTAP protocols in North America and Europe should be made to the WGE.

4. Collaboration and outreach.

How can more effective scientific and policy collaboration between countries be achieved

I. Linkage to Climate Change

Conclusions:

We need to link LRTAP strategies with greenhouse gases and aerosol emission reduction strategies, recognizing the cost effectiveness of addressing these issues at the same time and the simultaneous LRTAP pollution benefits brought about by CO_2 emission reductions.

Recommendations:

Countries should consider different energy scenarios for meeting their obligations under the FCCC in reporting future emission projections.

II. Linkages to Other International Fora

Conclusions:

The environmental goals of LRTAP are shared by other international fora (eg., UNEP Global POPs Convention, OSPAR, HELCOM).
Sources of pollution important to LRTAP are covered by agreements in other international fora (eg., IMO, ICAO).

Recommendations:

- EMEP and other LRTAP bodies need to continue co-operation with other international fora, such as IMO and ICAO, dealing with important sources like aircraft and ships.
- EMEP and other LRTAP bodies need to continue co-operation with other international fora dealing with important receptors, including marine (OSPAR, HELCOM) and Arctic (AMAP) environments, in the fields of eutrophication, heavy metals, and POPs.
- Co-operation on modelling and assessment should take place through the TF on Modelling and Monitoring and the TF on Emission Inventories and Projections.
- Collaboration on health effects should take place through the joint TF on Health Aspects and should take advantage of US-European Commission linkages provided by the Health Effects Institute (Cambridge, MA).

III. Trade and Environment

Conclusions:

Resulting from Article 3 of the Gothenburg Protocol, there is a need for consideration of future VOC controls for products. The European Commission has started investigating the scope for Community regulations on products.

The possible evolution from a cost effectiveness approach to a cost benefit approach dictates the need for further involvement of economists to research appropriate economic instruments and define the benefits of control measures.

Recommendation:

As part of the review of the Protocols, strategies should be developed to control emissions from certain products, on and off road vehicle standards, etc., in compliance with international trade agreements, taking into account developments in the European Community and North America.

3.5 WG 5: How to keep the interest?

Chair	Juha Kämäri	Rapporteur	Johan Kuylenstierna
Participants	Ramon Guardans Sofie Luyten Jennifer Steedman		John Thompson Jessica Thomson Christer Ågren

Introduction

Interest in regional air pollution issues peaked in mid 1980s to early 1990s with the focus on impacts on lakes and then forests. The overall interest in these issues has spread more widely throughout society in the last ten years, but the attention given specifically to the regional air pollution issues has decreased. The attention has shifted to global problems, particularly related to climate change and due to a perception that regional problems have reduced due to the success of the Protocols and other initiatives. However, problems related to regional air pollution remain and the discussions in this working group of the workshop focussed on how to regain attention to regional issues. Conclusions and recommendations from these discussions are described below.

How to increase attention?

Conclusions and Recommendations:

1. It is important to establish a communications strategy for the Convention, such as by the development of a communications group (e.g. ad-hoc committee formed by the EB) with a task to pro-actively define activities to communicate major activities, air pollution problems, findings and achievements of the convention to different stakeholders (including the public and industry);
2. Part of the communications strategy will be to further and actively develop Websites, the planning of which could form an important part of the Communication Group's activities. One of the activities could be to scan through related websites (e.g. ICPs) to evaluate potential and needs. This activity should actively consider provision of information for educational purposes and should include information as to 'what can I do?'
3. In addition to quantitative assessments of impacts it will be advisable to prepare and provide qualitative assessments and educational materials on, for example, impacts on nature reserves, threatened species, critical groups, cultural monuments and combined effects between regional and global air pollution issues;
4. It will be necessary to focus on important/emerging issues especially health (PM), materials and quality of life. Emphasis should be given to the role of the Convention in the development of international law and policy- science links;
5. A compilation and evaluation of the evolution of the LRTAP convention should be undertaken comprising:
    i. a short-term assessment on major conclusions;
    ii. a medium-term comprehensive compilation of the Convention evolution, problems along the way, and how these have been treated;
6. Highlighting costs and benefits using different scenarios showing what would have happened without protocols, and what will happen without further revision will be useful;

7. Further communication and the raising of attention will help to secure funding for country and affiliated institute studies related to the Convention;
8. It is recommended that Working Group and Executive Body meetings be more accessible.

1. Driving forces

Conclusion and Recommendations:

1 Do not to put all eggs into one basket. All impacts should continue to be considered. However, it is advisable to prioritise health impacts and materials damage (including cultural monuments);

2 There is a need to develop within the CLRTAP structure, a mechanism/structure to assess criteria and limits regarding health impacts for use in integrated assessments. A workable methodology needs to be produced from available data. In this context it is necessary to consider impacts resulting from both regional versus urban air pollution;

3 The general progress towards the inclusion of an effects based approach for materials damage in integrated assessment should be supported;

4 It will be important to use databases for nature reserves, important recreation areas etc. to identify areas at risk of high value to raise the profile of potential impacts.

2. Concepts and methods

Conclusion and Recommendations:

1 The emphasis on effects based approaches should be maintained and allowed to evolve;

2 The critical loads approach should be further developed towards a more probabilistic approach to account for uncertainties. Critical loads protecting resources to ensure sustainability are encouraged;

3 For impacts related to POPs and heavy metals, risk assessment approaches are more appropriate and should be developed;

4 Reported emissions data (with appropriate explanation) of high quality and up-to-date can create significant interest. Data broken down by sector at country level should be reported on Websites;

5 Common and transparent procedures to produce projections/scenarios of emissions should be developed;

6 It will be important to prepare a strategy on how to use the information and data. There is a need to show how the data from reporting will be used and analysed in order to encourage countries to supply data. Quality control procedures for the data need to be developed.

3. Science

Conclusions and Recommendations:

1 Data quality: A continued thorough assessment and review of underlying data in the integrated assessment, with an uncertainty analysis to identify where data can be improved, would be of great importance (including costs etc.);

2 Scientific research to support the Convention: In order to improve the knowledge funded science is required. It is important to continue to include CLRTAP needs in the EU framework programmes for research and development;
3 Publications: An improved and comprehensive list of scientific publications/articles relating to the CLRTAP should be made available on the Website.

4. Collaboration and outreach

Conclusions and Recommendations:

1 N America: Increased links across the Atlantic through some process on the technical level are needed – e.g. yearly bilateral meetings for information exchange, or other exchange of information (bulletins on the Web with on-going activities in both continents).
2 Links with Asia, Africa, Latin America: CLRTAP experience should be made available to regions of the World experiencing increases in emissions and impacts.
3 Links with the climate convention: Consistent scenarios should be developed in line with the Climate Convention.

5. Future strategies

Conclusions and Recommendations:

1 There is a need for higher quality data to improve the credibility of the research and information supporting further revisions of the protocol. There is a need for a peer-review mechanism for input data to integrated assessment;
2 It will be necessary to improve contact between the IAM modellers and country scientists to make sure that both groups agree on the use of data;
3 Stimulating ratification*:* The Secretariat should stimulate/ provoke parties to take action (e.g. to send letters to governments and use initiative in developing events);
4 The secretariat should promote provision of knowledge to the media, NGOs etc. The communication group in collaboration with the secretariat should decide on the best way to proceed.

6. The process

Conclusions and Recommendations:

1 How to achieve revisions: Focus on health (due to PM, O_3 etc.) in further revisions and include corrosion impacts. At same time improve the scientific basis concerning all aspects and impacts for future revisions. Credibility and reliability of data and results need to be improved;
2 It is necessary to implement existing obligations from current protocols and help countries to achieve implementation by developing methods to achieve implementation at national scale (maybe develop national IAM models);
3 Outreach activities need to be undertaken vigorously;
4 It will be important to create a Web-based bulletin to announce meetings and reports.

3.6 WG 6: Future Revision of CLRTAP Protocols and Strategies and Linkage to Countries

Chair	Øystein Hov	Rapporteur	Juergen Schneider
Participants	Ronald Alberts Rémy Bouscaren Lars Björkbom Eduard Dame Steve G Hart Helmut Hojeski Dusan Hrcek Rolf Lidskog		Marisol Lorente Carla Mazziotti Ulrik Torp Robert Tóth Roel Van Aalst Fredrik Wiesemann Sonja Vidic

1. Driving Forces

What is needed to keep the process going?

- Keep the network of institutions and people; anchoring of science and policies in organisations and countries is essential;
- Technology transfer, support between countries, etc. is laid down in the protocols, but have to be strengthened in practise;
- Promote the idea of partnership (give and gain);
- Health effects is a growing driving force in many countries;
- More emphasis has to be put on the description and quantifying the benefits of emission reductions. This will enhance the support of the population and could provide pressure necessary to continue.

Technical:

- Increase the focus on ozone, PM and toxics (impact of low level toxics).
- A stable link between regional pollution issues with climate change issues is needed.
- It is necessary to find a way to tackle the effects (e.g. emissions) of increased traffic (East-West trade).

2. Concepts and methods

The working methods proved to be successful; therefore keep

- Trans-national networks;
- Effects based approach;
- Use the success of the CLRTAP to build public support

but:

Integration of additional environmental issues is needed

- new pollutants (PM, HM, POPs);
- different scales (local, regional, hemispheric);
- coherent with other strategies (EU, UNFCCC);
- include non-technical measures;

3. Science

- EMEP must be kept and reinforced as a powerful scientific instrument;
- Emphasis on quality and comparability of data, especially, where accumulated data are used for the elaboration and assessment of emission reductions and their effects on the environment;
- Analyse in more detail the role of LRTAP in the Mediterranean countries (ozone, PM);
- Environmental changes, human health issues and effects on materials including cultural heritage should be included in cost benefit analyses;
- Maintain and improve transparency;
- The commitment of parties to foster science has to be emphasised;
- Common funding mechanism?

4. Collaboration and outreach

- Within international agreements some degree of flexibility is necessary;
- It is primarily the responsibility of the states to develop coherent strategies to comply with different obligations;
- CLRTAP has a weak and financial structure, partly relying on voluntary contributions from lead countries;
- On a technical level, the possibility of the mutual use of data and the streamlining of efforts (science, reporting,..) should be inquired carefully;
- Outreach across organisational, geographical and compartimental borders to enhance collaboration and mutual strengthening of the underpinning of e.g. CLRTAP, HELCOM, OSPARCOM, Barcelona and Black Sea Conventions, ICAO, IMO.

5. Future strategies

- Environmental problems are not solved!
- It is fundamental to raise public awareness of what has been achieved and what has to be achieved. This is essential to speed the process of ratifying and enter into force of the last three protocols.
- The use of one model (fed with national data) proved to be successful. Anyhow, the scientific basis for each part of the model can be improved.
- The underlying assumptions of current protocols need to be continuously evaluated and improved to prepare for revisions and to assess the benefits and improvements.
- The possibility of national measures (product regulations, traffic and trade) is decreasing; international co-operation is becoming more and more important.

6. Stakeholders

- There is a significant shift in pressure groups from environmental NGOs to strong lobby groups with significant economic interest in promoting specific policies for emission changes (transport, trade, power production, industry,...).

3.7 WG 7: Cost Benefits

Chair	Keith Puckett	Rapporteur	Eivind Selvig
Participants	Keith Bull		Per Erik Karlsson
	Radovan Chrast		Guy Landrieu
	Peringe Grennfelt		Rachel Warren
	Tor Johannessen		Henning Wuester

1. Driving forces

What are likely to be the driving forces for air pollution control in Europe and North America over the next 5-15 years?

Conclusions:

The overall driving force will remain an approach based on the recognition of effects associated with air pollution. However, the fact that incremental measures to reduce air pollution even further will be at a higher cost will results in more emphasis being placed on the costs and benefits of these measures in the decision- making process.

Governments are sensitive to public opinion, Another force will therefore be the political and public interest in further addressing the air pollution and associated effects. The perception of having successfully addressing the issue as reflected by the various protocols will lower the profile in the general population . The needs to be a continuing and effective means of ensuring that public support is maintained.

The driving forces for air pollution control in the near term include the increasing significance and awareness of the human health impacts of current air pollution levels in Europe and North America. The effects on the environment are not to be discounted but the new understanding of the influence of air pollution on human health would mean that any revised protocol which did not take this into consideration would be lacking an important element. This human health impact includes considerations of not only the direct and short term effects associated with poor air quality but also the longer term and potentially inter-generation impacts associated with more persistent chemicals.

In the longer term, the issue of climate change and the means to address it will play a significant role in any consideration of further measures to improve air quality in Europe and North America. The climate change issue will probably introduce or set in motion more fundamental structural changes which will produce a long term pressure on air pollution levels . The co-benefits will be more/cheaper changes in SOx/NOx, VOC levels and improved air quality . The CLRTAP has to take advantage of this major influence on air quality.

Recommendation:

- Focus on co-benefits and no regret measures.
- Consider health impacts from a broad perspective.

2. Concepts and Methods

Will present concepts and methods used for air pollution strategies and policies in Europe and North America be appropriate for the future ?

Conclusions:

A. Existing methods and the short term.
Present concepts and methods are appropriate for the future development of revised protocols over the next 3-5 years even though the concepts and practices are dated. Existing methods, effects based using a cost effectiveness approach, have proved to be effective in facilitating agreements and should be maintained . In addition, current methods and data bases although limited are familiar to policymakers and scientists alike and are judged to be robust, transparent and fair. Introducing new techniques at this time would imply a considerable investment in ensuring a similar level of comfort. Some modifications were suggested to improve the methods in use. These suggestions included moving away from steady state models to more dynamic models to address ecosystem recovery, for example.

B. New methods and the longer term.
A cost-benefit approach was judged to be a natural progression as more information became available on the benefits associated with control measures being implemented and the different health and environmental effects.

On the longer term, adopting the concept of sustainable development would allow targets to be formulated in terms of indicators of sustainability rather than the existing critical load concept. This broader perspective would allow other considerations to be factored into describing the overall impacts of acidification including the role of land use changes and climate change.

Indoor air quality and the contribution from long range transport was seen as a factor contributing to the definition of personal exposure, a key consideration in addressing the human health impacts of air quality and particularly the role of particulate matter. However, while recognising this linkage, it was considered premature to promote addressing indoor air quality as one means to further the goals of the CLRTAP.

In contrast, embracing the sustainable development concept would naturally include consideration of the marine environment and the role of atmospheric deposition in marine pollution. Given the Conventions in place to address marine pollution, the most appropriate approach in the interim would be to continue to harmonise the activities of these conventions with CLRTAP.

Recommendations:

- Keep the present concepts but improve the quality of the data
- Introduce recovery time using a dynamic perspective
- Carefully introduce an approach to the development of broad sustainable indicators to reflect the overall stress on ecosystems.

3. Science.

What scientific knowledge, data and models are available [or might become available] to aid policy development for international and national policy bodies in Europe and North America.

Conclusions:

Currently there is emphasis in North America on characterising the emissions, atmospheric levels and physical/chemical characteristics of particulate matter in urban and regional environments. This information will yield insights into the significance of primary and secondary emissions and source identification.

In general there should be continued emphasis on improving the reporting and the quality of emissions, with particular emphasis being placed on primary particulate matter estimates. In addition, there needs to be accelerated efforts to define the causal relationship between PM concentrations and human health endpoints. However, it is unlikely that definitive statements on causality will be available prior to protocol renegotiations.

The scientific link between climate change and issues of concern to the Convention should continue to be emphasised. The understanding of the radiative forcing characteristics of particulates and the significance of tropospheric ozone as a greenhouse gas will continue to develop as global climate models are further developed.

Scientific information will be available in the near future which describes the relationship between ozone fluxes and vegetation damage in contrast to earlier relationships between ozone concentration and damage with implications for the current geographical distribution of emission reductions.

However, one information gap that will not be resolved in the near future is an appropriate criterion for expressing dose-response relationships for the impact of acidification on forest productivity. The current use of the Ca/Al ratio is appropriate for defining critical loads but does not lend itself to defining the dose-response function.

National maps of critical loads will be modified but a ”seamless” European-wide map is not available as yet.

In terms of the atmospheric transport models for acidifying emissions and oxidants, the current models will still be relevant for application in the near future. The temporal resolution is appropriate and the continued efforts to address finer and finer resolution are appropriate in the context of furthering efforts to better define effects. In this context, inclusion of deposition estimates of base cations in modelling schemes would be justified as would further consideration of the influence of complex terrain on deposition estimates.

Enough model output and monitoring data should be available to address the question of estimating the costs and benefits from control measures already in place. Such an analysis could be produced prior to the revision of the multiple emissions: multiple effects protocol.

Energy and global warming scenario's should examined by the Convention to assess the significance of co-benefits in reducing acidifying emissions and oxidant precursors.

The possible evolution from a cost effectiveness approach to a cost benefit approach dictates the need for further involvement of economists to research appropriate economic instruments and define the benefits of control measures.

Recommendations:

- Accelerate research on the health impacts of PM.
- Continue to improve emission inventories with emphasis on PM.
- Implement a review of approaches to national critical load maps.
- Verify benefits and costs of measures already in place.

4. Collaboration and outreach.

How can more effective scientific and policy collaboration between countries be achieved ?

Conclusions:

The CLRTAP Science program is seen as a major contributor to the success of the Convention. One obstacle to the continued effectiveness of the science program in delivering appropriate tools and data is the decline for funding for scientific activities by national funding agencies.

Some existing frameworks serve to facilitate research collaboration e.g. EUROTRAC but this is restricted for the most part to European university researchers and is limited to atmospheric transport and transformation studies. There is no comparable framework to promote effects research. US and Canadian involvement with European researchers is through bilateral agreements between states e.g. Canada -Germany.

There is no comprehensive communication strategy to the broader scientific community which would promote awareness of the CLRTAP science program and facilitate collaboration.

Recommendations.

- National funding agencies should be encouraged to provide appropriate funding levels.
- The TF on Modelling and Monitoring meetings not be restricted to CLRTAP officials and EMEP centre staff.
- A communications strategy should be designed and implemented.

5. Future strategies

What might a revised Gothenburg Protocol [and Aarhus Protocol] look like and what strategy do we adopt to get there?

Conclusions:

Public and political interest has to be at least maintained and at best enhanced so that environmental issues have an appropriate profile in the period leading up to renegotiations.

The revised Gothenburg Protocol would have more emphasis on addressing particulate matter. On co-benefit of this approach is that metals and certain POP's [dioxins/furans, some PAH's] are associated with particles and measures to reduce particulate emissions may impact metal and POP emissions as well.

The Gothenburg Protocol is step in the right direction in attempting to meet critical loads but there is still a way to go as is evident from the large areas where deposition is still in excess of the critical loads.

Recommendations:

- A communications strategy should be designed and implemented.
- A revised protocol should aim at tightening existing emission levels and give more prominence to the significance of marine and aviation emissions.
- The revised protocol should include measures to address the human health and ecosystem impacts of PM2.5.

3.8 WG 8: Integrated Assessment Modelling

Chair	Rob Maas	Rapporteur	Matti Johansson
Participants	Markus Amann Helena ApSimon Jesper Bak Guiseppe Brusasca Cornelis Cuvelier Anette Einarsen Pavel Jilek Isabelle Lecuyer		Kerstin Lövgren Sophia Mylona Otto Rentz Henk Schipper Anna Spain Catarina Sternhufvud Göran Sundqvist Leonor Tarrason

1. Driving forces

Conclusions and recommendations:

- Health effects are the most important driving force in the next 5–15 years. These effects arise mainly due to particulate matter (PM_{10}, fine $PM_{2.5}$ and ultrafine $PM_{0.1}$), but also heavy metals and persistent organic pollutants may play a role.
- Biodiversity due to nitrogen deposition is the second important issue in future work, partly coupled with the effects of land use changes. The climate change policy and technological progress will introduce more ambitious efforts in the policy approach for current UN/ECE/CLRTAP protocols. The remaining exceedances of critical loads in 2010 will be not enough to stay the main environmental issue.
- Ammonium is probably crucial for both health effects through secondary particulate matter formation and biodiversity through excess eutrophying nitrogen deposition.

2. Concepts and methods

Conclusions and recommendations:

- A(n integrated) modelling approach is needed for further assessment work, but it can be supported by other approaches (*e.g.* risk assessment, application of best available technologies) when available.
- The new assessment on particulate matter should be carried out within the current integrated modelling scheme. The technical model development is strongly affected by spatial scaling requirements, *e.g.* extensions and connections to both global and local scales.

<u>Integration of scales</u>

- The modelling approach in the future should focus on transboundary regional long-term aspects as earlier. This should also guide the efforts in modelling and linking of data and knowledge.
- The most important linkage is in scales, which should comprise global, regional, local and indoor air quality aspects.
- Other important linking required will be on models, knowledge, policies and abatement measures.
- Only simple linking is first needed to include particulate matter in integrated modelling to pinpoint the most important areas for further assessment and

data/knowledge requirements. A supermodel including all possible assessment aspects and details may not be appropriate or possible, but the interaction between compatible scales and models will be defined based on recognised most important assessment needs.

Transparency and complexity

- There is a trade-off between modelling complexity and transparency. The inclusion of details should be done in submodels (or satellite models), which would include sectoral and local specifics for particular assessment purposes.
- Active participation of countries is extremely important to include major characteristics in modelling, to check the appropriateness of input data, and especially to convey findings to all stakeholders. The stakeholders should secure necessary long-term resources for carrying out the interaction between national and international modelling and assessment processes.

Critical load approach

- Current information on particulate matter suggests, that there are no thresholds for health effects due to particulate matter. Therefore, the critical load approach as such may not be suitable, but rather a low risk target could be set as a proxy.
- The current transboundary regional long-term approach should be kept, although current observational data and local modelling may emphasise episodic events. The effect pathway should be streamlined for the modelling purposes, taking into account as much as possible the particulate matter type due to differences in size and chemical composition, for which more information will be available in the future.
- The introduction of particulate matter in integrated assessment modelling will create a major challenge to uncertainty management, which should be one of the main focuses in the forthcoming work.
- A workshop on health indicator concepts should be organised.
- An expert meeting on organic particulate matter should be organised.

Subnational breakdown of emissions and costs

- Emissions for different activity sectors and (marginal) costs in the countries could be part of a more detailed assessment of modelling results.
- The modelling tools could provide the possibility to assess the changes in spatial emission patterns, however, this would require extensive extra resources.

3. Science

Conclusions and recommendations:

- Scientific improvements in emission projection input
    - activity projections
    - link with UN/FCCC-reporting, which is obligatory for the countries, especially on energy and activity data
    - policy already in place
- Scientific improvements in monitoring
    - further monitoring of environmental changes in relevant ecosystems
    - identify missing air quality monitoring stations based on optimised EMEP observation network

- Scientific improvements in modelling
  - compare measurements and (dynamic) model results in the countries for verification purposes
  - evaluate effectiveness of policies
  - adapt models, if necessary
- Improvements in integrated assessment models
  - Develop and maintain a detailed abatement options database, including emerging technologies (2020 or beyond) with JRC-Seville, industry expertise and others.
  - Organise workshop on (alternative) methods to calculate abatement costs (especially structural changes); the importance of the discount rate can be assessed by countries at national level; it should be noted that the aim of the cost curve approach in integrated assessment modelling is to act as a tool in setting priorities between different control measures, but not to predict in high detail the actual costs of individual control cases.
  - Evaluate alternative optimisation options, but they should be kept simple and transparent without adding to modelling and assessment complexity.
  - The sensitivity and uncertainty analyses should focus on identification of robust, no-regret measures. The parties should perform themselves sensitivity and uncertainty analyses on their input data.
  - The (intense) interaction between scientists and policy makers should be maintained. The stakeholder participation should be further increased at the national level. Capacity building should be enhanced especially in central and eastern European countries, *e.g.* through joint research projects.
  - A coherent set of targeted workshops should be developed for integrated modelling groups and experts. There should be an exchange of experiences with national experts via workshops, *e.g.* within the Auto/Oil program, urban modellers, UN/FCCC scientists, experts from other continents *etc.*
  - Make the UN/ECE/CLRTAP-network more transparent to outsiders.

4. Collaboration

Conclusions and recommendations:

- Further enhanced co-operation in the scientific work is required between EU and UN/ECE/CLRTAP.
- It is necessary to create expert linkages with UN/FCCC, HELCOM/OSPARCOM, IMO/ICAO and other relevant organisations.

5. Future strategies

Conclusions and recommendations:

- Abatement policies should be assessed with integrated assessment models for those heavy metals on persistent organic pollutants, which create significant damage to health and ecosystems and where their critical thresholds are greater than zero. Otherwise, the objective for those pollutants is the minimisation of emissions.
- A revised protocol should be based on integrated assessment models that incorporate:
  - Particulate matter
  - Level-2 approach for ground-level ozone
  - Links between regional and urban air quality, including the chemical non-linearity
  - Links with climate change policies

·Biodiversity losses due to excess eutrophying nitrogen deposition
·Dynamic description of effects
·The focusing on remaining hot spot areas

6. Process

Conclusions and recommendations:

- Data, models and documentation should be made available to the parties, preferably easily accessible via the internet.
- The methods used in integrated assessment should be published in peer-reviewed journals.

4 Abstracts

4.1 Opening Statement

Måns Lönnroth
Mistra

Mr Chairman,
Ladies and Gentlemen, Dear Friends and Colleagues

I wonder if any international environmental agreement has been as successful as the UN ECE Convention on Long Range Transboundary Air Pollution. From the first initiative in 1969 in OECD to the Convention itself in 1979, from the first protocol in 1984 to the 1998 Århus Protocol and the 1999 Göteborg Protocol – this is indeed a very major achievement.

A whole generation of scientists and policy-makers and indeed politicians have made this process their own. Thanks to them - to you - emissions are being reduced and our understanding of the basic scientific issues is improving. Moreover, it is a decidedly open-ended process.

In one sense, the process is reinventing itself. The first protocols on flat reductions of SOx, NOx and VOC have been followed by more complex versions and combinations with the Göteborg protocol as the first ”multi-multi” achievement. New pollutants are being added such as Persistent Organic Pollutants and Heavy Metals.

The process is also reinventing itself geographically. A UN ECE brochure from, I think, the Århus meeting in 1998 mentions also the transport of POPs to the Arctic region and the fact that persistent organic pollutants and heavy metals have been found to accumulate in arctic food chains. The POPs Protocol sets a precedent for the global POPs Convention, much as the North Sea Conferences set precedents for the OSPAR Commission meetings. Studies are also underway on regions outside Europe such as Asia and North America. Maybe the Convention will turn into a Convention for the whole of the Northern Hemisphere, with different protocols for different regions.

The aim of this work-shop is to look 5 to 10 years ahead with the next revisions scheduled to take place in 2005. The EU Directive on National Emissions Ceilings will probably be revisited by the same time or a couple of years later. I would like to inject some reflections on these coming years based on my own interpretation of the last ten or so years.

I do think that ten years is an appropriate period for reflection. The 1980's were to a large extent an investment period, a period of ”getting to know each other”, of testing ideas, of investing in methodology, people and trust across national borders. Those investments matured out into the achievements of the 1990's. Let us reflect on some of the decisive factors.

My own list has five items: 1) science, 2) consistent overestimates of abatement costs, 3) outside events, 4) results and 5) timing. Let us run through them one after one.

First Science. Without the scientific network created during the 1970's and 1980's the present achievements could not have been reached. It is the combination of atmosphere chemistry, meteorology, geology, medicine and many other disciplines that have made success possible. If one science should be mentioned before others it is, I think, meteorology. I wonder if it is not the mathematical tools of meteorology that have made the trans-disciplinary and trans-boundary integration of the other disciplines possible. I think this role of applied mathematics hides a deep lesson for environmental sciences in general. I say this not the least after having watched other international environmental agreements that lack a similar stringent quantitative basis.

Second, overestimates of abatement costs. This became very evident already during the 1980's. Sulphur reductions were much easier to achieve than the industrial pessimists claimed. This, I think, having watched it from the policy end, had two fundamental effects: new pollution abatement industries were created and government policy makers became less wary of commitments.

Third, outside events. Now, what do I mean with outside events? I mean events that scientists and policy makers involved directly with the Convention and its protocols did not foresee but which nevertheless have had profound effects. Let me list the most important events:

- The change of heart of the German Government in the early 1980's.
- Natural gas from the North Sea and Siberia.
- Mrs Thatcher's drive to privatise the UK electricity industry in the late 1980's, which made, or forced, her to give up her resistance towards the Large Scale Combustion Plant directive.
- The first democratic Government in Poland in May 1989 which triggered the chain of events that finally led to the German reunification and the break-up of the Soviet Union.
- The early 1990's privatisation of the UK coal mining industry, which finally broke up the iron triangle coal-electricity-Department of Trade and Industry.
- The European Union enlargement from 12 to 15 members in 1995.
- The Globalisation of the European car industry, which finally broke the Southern European resistance to strict car emission standards in the late 1990's.

I am going through this list at some detail because I think that all of us working in and around the Convention have to appreciate how formative all these events actually have been for the convention. No Convention is an island. Either.

Fourth, results. The Convention and its protocols have created its own virtuous circle in the form of a constituency in the wider body-politic solely on the basis of results. Improvements have been noted. The air has become cleaner. The acid deposition is lower now than ten years ago. This again reinforces the virtuous circle.

Fifth and finally - timing. I wish to single out timing for one very specific reason. I am concerned with the unfortunate timing of the Göteborg Protocol in relation to the EU directive on the National Emissions Ceilings. Originally, the directive was scheduled to be decided before the completion of the Göteborg Protocol. Since the EU in many ways is a tougher negotiations arena than the Convention I think that an already concluded directive would have led to a tighter Protocol in Göteborg.

The resignation of the Commission one year ago threw a spanner in the works of the negotiators. We now run the risk of having a weaker NEC directive than what could otherwise have been achieved.

Which is a good point of departure for looking at the coming 5 to 10 years. Let me run through my five factors again, in the reverse order. My conclusions would be the following:

First, think through the timing between the next revision of the protocols and the main EU directives. The decision making process in the European Union with co-decision between the councils and the European Parliament is more open than the government-to-government negotiations of conventions and protocols. I think this would work for the benefit of tight agreements.

Second, take a close look at results that may widen the political constituency of the Convention and its protocols. Added emphasis should be given to human health issues in major European cities and to preserving Europe's cultural heritage. I find it a tragedy that the Acropolis in Athens and Trajan's colon on the Forum in Rome are still threatened by air pollution. They have been there for 2000 years - and now we let the dirty fuels from the oil industry destroy them through car emissions.

Third, think through some of the outside events that might give added leverage for tightening the protocols. Declaring the North Sea a special area of the IMO would open up the possibilities to get at maritime emissions. Electricity market liberalisation will - or should - need harmonised emission standards, which should give added leverage. And what will the coming EU enlargement from EU15 to, perhaps, EU20 and then perhaps EU25 mean for the Convention ?

Fourth, costs. The present RAINs model runs the risks of overestimating costs significantly and this is creating all sorts of resistance towards tightening the protocols and the relevant directives. One of the most important developments of the RAINs model would be to incorporate the possible effects of the flexible mechanisms of the Kyoto protocol. European wide CO2 emissions trading should work towards reducing the LRTAP emissions. But it may be necessary to think through how the Convention is affected by emissions trading in general.

Fifth and finally - science. The scientific basis of the convention and its protocols needs further strengthening. At the same time, simple concepts should not be sacrificed that have made the protocols understandable for that wider audience which is the main constituency of policy makers and in the end government ministers. Simplicity is a fine art in need of constant practice. Policy makers, journalists and government ministers are always pressed for time and attention. Never forget that the duty of scientists is also to explain to laymen.

Let me conclude by some thoughts on the changing nature of international agreements, inspired by an article on "the end of the Westphalian order" in Foreign Affairs a couple of years ago written by Jessica Mathews, presently at the Carnegie Endowment for International Peace. The Convention is a convention between governments, negotiated in a relatively closed process as are all agreements between governments. Some say that this goes back to the Peace of Westphalia some 352 years ago. The Thirty years war in what is now Germany ended up by deciding that international politics was the prerogative of national governments.

This international order has been very effective but is has its draw-backs. It is a closed system, with national administrations negotiating between themselves and balancing, as it were, their respective national interests. Jessica Mathews argues that the end of the Cold War also signifies the rise of a global civil society, which redistributes power among states, markets and civil society. NGO's using CNN and the Internet broke up the proposed Multilateral Agreement on Investments but made the agreement on anti-personnel mines possible in the face of opposition of most governments.

Maybe the LRTAP Convention will transform itself from a purely government-to-government vehicle to a hybrid organisation, where governments, international organisations, NGO's and science together shape the future. Who but science can speak for the inuits and the polar bears in the traditional Westphalian order?

Dear friends, this workshop is an important event in the development of the Convention. Scientists as well as policy makers from Europe and North America are here and you have a full agenda in front of you during the next three days. The 1990's has been a decade both very successful and also full of surprises. This workshop marks the starting of the next decade, the third of the convention. We are many people who wish you luck and success.
Thank You!

4.2 Experiences from the Process Leading to the CLRTAP Protocol to Abate Acidification, Eutrophication and Ground-level Ozone and Expectations for the Future

Lars Björkbom
CLRTAP (Former Chairman)Working Group on Strategies

Dear former Colleagues, old Friends and Newcomers,

The timing of this workshop is excellent and I thank the ASTA programme, the Nordic Council of Ministers and the SEPA for taking this initiative. We have recently finalised a phase in the history of the CLRTAP and have had some month to reflect and assess experiences. We can also foresee a period in front of us when most of you and some further newcomers will be involved in preparing for a review process and the review itself of the multipollutant/multieffect protocol, the latter which will probably take place about 2005. As the ASTA programme is mainly focused on acidification, eutrophication and ground-level ozone my reflections on the past and my guesses for the future will also focus on the same subject areas. Some of the reflections and guesses might also have relevance for the POPs and heavy metals protocols.

When looking at the past as well as the future I shall consider the political, epistemological and organisational contexts:

Why was the process to achieve the Gothenburg Protocol so successful? I know that there are varying opinions about the ambition level as expressed in national reduction targets, but I do think that everyone is prepared to agree when I say that the five/six years process (1994-1999) was surprisingly successful as it mastered a number of political, scientific and organisational problems.

The political context:

There was relative stability in national politics and international affairs in the CLRTAP region. With the exception of the Balkan and the Caucasian conflicts there were no major upheavals in national politics, less than usual frequencies of changes in national governments and no major international conflicts in the region to disturb the preparatory and negotiation processes.

The ”EU magnet” was still attracting governments in Central and Eastern Europe. The overriding wish by many CECs to become members of the European Union for security and economic political reasons has given increased strength to the environmental interests in these countries as they are aware of the need for each country also to adopt EU environmental legislation to become EU member states.

Moderate political dynamics behind the process in most countries. You may wonder why this should be looked upon as an asset? My answer is that this lack of overall hard political pushiness gave all the people involved in the preparatory and negotiating process the necessary time to develop scientific tools and close essential knowledge gaps and establishing a common understanding between scientists/experts and policy advisors/negotiators of what could be achieved by the strategy adopted towards the protocol. Had we had eager environment ministers behind our backs demanding quick results I dare say we should not have had the possibility to implement our strategy.

You may express the same by noting that there were no major divisions of opinion in national party politics about the objective of the foreseen protocol.

May I finally add that there was a high degree of interactive and constructive tolerance among all negotiating Parties admitting different solutions for CECs, EU(+CH and No) and North America. I see this as a maturing of international environmental politics, where you do accept differences of priorities, legal and administrative musts that have to be met differently by different countries. This maturing was probably a *sine qua non* for having such a large group of countries as serious negotiators all through the process.

The ”epistemological” context:

(This, I take it, will be one of the main themes at this workshop. Many will have much better understanding of this than I have, but I shall briefly outline some points that I feel were especially important.)

There were all through the process a clear interest in highly qualified scientific and other experts communities to probe the limits of the critical loads/critical levels concept.

There were major scientific challenges to master non-linear behaviour of pollutants in the atmosphere.

There was still a belief or hope in scientific and policy making communities in most countries that you can ”control” socio/economic futures through system analysis and integrated assessment modelling.

There was a remarkable readiness of scientific and other expert key actors involved to remain on the ”band wagon” during an extended period. This certainly helped to give stability to the development and materialisation of the strategy behind the protocol. The price was an element of ”closed shop”, that for different reasons might be dangerous and should be observed for the future development. But in this initial phase I am sure that this closed shop character was essential to achieve the results we did.

I will finally add that the above constructive performances were (partially) depending on ”lead country” financing and the merger of approaches in the CLRTAP and the EU.

The ”organisational” context:

An intergovernmental institution of the kind that the CLRTAP represents is inherently a weak organisation. It has very limited financial resources and Member states resources to follow and take part in all the aspects involved in the complicated strategy used for the protocol are also limited because of lacking budgetary means and expertise competence in many fields. In spite of these shortcomings the long process could be kept together and land well by all Parties accepting flexible approaches in organisation and financing as we went along. There are five points I wish to highlight:

There was a well functioning network between people involved in the work under WG on Effects, EMEP SB and the TF on integrated assessment modelling and the WG on Strategies and the Executive Body and the formal decision making process could thus be made much shorter. The new structure, where chairs of the working groups became ”ex officio” members of the EB Bureau helped much to give concerted leadership to the whole process.

There were small changes of ”actors” both in the scientific and other expers communities and among the negotiators in WGS, which highly facilitated the interactive learning process between ”science” and policy advisers/makers.

The harmonisation of air pollution abatement strategies between the CLRTAP and the European Commission was a necessary element in the process. I wish also to underline the important role that IIASA did play in this context.

It was all the way through the process clear that there was readiness among member countries to organise and finance workshops and expert meetings. This was also an important element in the ”learning process” and gave good opportunities to tighten the network among all actors and participants involved in the process.

May I also add the unusual readiness among member countries working in the French and Russian languages to accept English as the *lingua franca* in all meetings lacking interpretation. This forthcoming attitude (which is very rare in other similar international institutions) was not only a sign of the necessary trust that delegations had for each other but also helped to facilitate and speed up the process.

Finally I must, of course, add the very good support that the process got from the UNECE Secretariat - whose resources and good will was strained to the utmost by all involved delegations and not least by myself and other members of the EB Bureau.

There could, of course, be much more to add, but that will be a matter for other opportunities. I am planning to write a book myself and the literature on various aspects of the CLRTAP history is today voluminous and some of it contains rich insights into the process, that I have just described.

Then, let us look at the future and I am considering the nearest five to ten years from now, when the Protocol should have entered into effect, a first review process been finalised and the national obligations under the Protocol should have been implemented and use the same three contexts as I used for the recent past. Of course, what I can say can only be guesswork. The only thing that I can take for granted is that the contents of the contexts, for sure, will be different than those that ruled the past.

What can be crucial to the future process under the CLRTAP and the multieffects/multipollution Protocol in the political context:

The further enlargement of the EU? If the process of getting all incumbent countries in Central and Eastern Europe into the EU will become a smooth process this could only favour the CLRTAP process. But I think you would all agree with me that the political and economic issues which have to be resolved are formidable and only a poor student of international and national history and politics would say that there will only be harmonious and peaceful developments in the process. Therefore, I think that you have to be prepared to encounter a much more difficult political climate behind the CLRTAP process than was the case over the last few years.

Who will govern the USA from 2001? Should it be a conservative and protectionist Administration and Congress I fear that this would have negative repercussions also in the CLRTAP sphere. There, we have over most of the last decade got used to a mounting interest of US involvement in CLRTAP affairs (which, I deem, have been a valuable and mostly constructive involvement) and a change in the US interest could only be to the worse, seen from a CLRTAP perspective.

Developments in the Russian federation are less than knowable. But for the substantive role of the CLRTAP in the abatement of European and North American air pollution it will be, as it has been, very important that this huge country takes its fair and large share effectively. RF´s capacity and possibility to master its emissions of most of the pollutants addressed under the CLRTAP is crucial to the fate of a Clean Air Europe and North America and also for the plain sailing during the process which we are here considering.

I also think that we must be aware of the political and substantial impact on the CLRTAP process of the future developments of Climate Change Control

And, finally:

What attitudes to further abatement controls can we expect in countries, in which ecosystems will be reasonably well protected and the human health situation are deemed to be acceptable (according to their own political evaluation), when the present Protocol(s) will have been implemented?

What about the ”epistemological” context?

Will there be ”surprises” effecting our knowledge base? Will there be many newcomers to the scientific/expertise network over the last decade and thus (possibly) new scientific approaches to the problems involved? Will most of the key actors from the last decade remain and dominate the relevant R&D?

Will the strategy which has been guiding the Protocol and the remit for its review be considered sacrosanct? From the formal point of view the strategy is integrated into the legal clauses of the Protocol. But if there will be strong pressure from the scientific and/or the policy making communities to find new venues to achieve the objectives of the Protocol, will that open up for new strategies and thus obliterate or minimise the claim that the Protocol is designed to stand the test of time. And what could be the implication of once again opening up Pandoras box that was so nicely shut during the nineties?

And then, of course, the eternal question: **Will there be sufficient financial support for scientific development in relevant fields of research?** The efforts from the EB

Bureau and the Working Group on Strategies to find acceptance among all Parties for assessed (voluntary or mandatory) financial contributions for work under the Working Group on Effects and for integrated assessment modelling has so far been unsuccessful. An acceptable solution to this issue should, according to my judgement, be given the highest priority by the EB.

I have only some few remarks relating to the "organisational" context:

I think that new efforts should be made for "outreach". This matter has been discussed many times in the past by those involved in the CLRTAP process, but so far very little has materialised from these efforts. To me, it is quite clear, that no one with access to present day knowledge on the distribution of transboundary air pollution, would have considered the UNECE region as an ideal geographical limitation and only considering effects of these pollutants in land based ecosystems to be the optimal way of organising international abatement policies and responses. But we are in the hands of past historical developments and should wisely judge, that efforts to reinstitutionalise the institutional fabric of international environmental co-operation to meet today's considered needs would probably not be very successful for a number of reasons that many or most of you are aware of. But it is also quite clear that the CLRTAP process to become long-term effective must establish constructive relationships with regional institutions outside the CLRTAP geographical area (*e.g.* ESCAP) or relevant global conventions or institutions (*e.g.* CCC, UNEP, IMO, ICAO). It is equally clear that much could be gained by renewed efforts to establish constructive relationships with relevant regional conventions/institutions inside the CLRTAP area (*e.g.* HELCOM, OSPARCOM; AMAP).

I finally think that you should reflect on the following question**:** Will national governments be the obvious future main actors in international air pollution abatement policy formulation and implementation?, or, should there be an outreach to non-governmental actors (*e.g.* actors on a deregulated energy market or farmers' unions)? But, also, could such an outreach be managed by an intergovernmental institution, like the CLRTAP?

Thank you for your attention. Only now and then I shall envy those of you who shall be instrumental in meeting the challenges of CLRTAP problems over the next decade.

4.3 The Experiences of Regional Air Pollution Strategies and Prospects for the Future: The EU Perspective

Martin Lutz,
European Commission,
DG for Environment

1. Where are we – a need for reflection!

The Gothenburg protocol is due for ratification by the Parties to the CLRTAP within the next few years. At the same time the proposal for a Community Directive on national emission ceilings (NEC) and for an new ozone Directive (COM (99)125[1]) is being discussed in the Council and the European Parliament with the view of adoption in the course of 2001. Both processes take the same effects – based approach and, to a large extent, share the same scientific models and databases. Also the effects related indicators and long-term objectives for reducing acidification, eutrophication and ground-level ozone are equivalent.

The EU legal framework, however, also includes air quality legislation, which requires air quality standards for several pollutants to be achieved within a given period. For example, the proposed ozone daughter Directive contains long-term objectives and target values for 2010 that are consistent with the environmental objectives used for deriving the NECs. Non-attainment of the ozone target values may trigger additional action than the NEC-based strategy provides. The target values are a politically visible environmental goal against which progress of control strategies have to be monitored.

All existing and proposed EU legislation on air quality as well as the NEC proposal share a common requirement for revision by 2004. This coincides well with a review of the Gothenburg protocol. Revising the emission ceilings is of crucial importance in the light of the following political developments which significantly affect implementation of the ceilings:

- Enlargement of the European Union
- Climate change policies driven by the Kyoto commitment to reduce greenhouse gas emissions and therefore energy consumption.
- International agreements on the emissions of sources beyond the scope of Community legislation (e.g. emission from international shipping and aviation)

At the same time the Commission has to come forward with a revision of other air quality legislation, notably with a review of the ozone standards and with revised limit values for fine particles (PM). Rather than pursuing that separately for each pollutant the review ought to be undertaken as part of an integral strategy covering all relevant pollutants, including acidification and eutrophication.

[1] See the Commission web-page: http://europa.eu.int/comm/environment/docum/99125sm.htm

2. What will drive a future strategy on transboundary air pollution control in Europe

The following problem areas will have to be tackled by a European-wide air pollution abatement strategy, listed in the suggested order of importance:

- Fine particles (PM) constitute a major threat to human health. A large part of the PM concentration originates from secondary aerosol formed from the same pollutants as covered by the NEC Directive and the Protocol. Together with the ultra-fine fraction of primary PM secondary particles represent the transboundary part of the PM problem. Therefore, integrating PM into a revised acidification, eutrophication and ozone strategy would enhance the efficacy and cost-effectiveness of the whole policy. The difficulty with PM is, however, that it is the field with the largest gaps in knowledge on effects, sources, control potentials and costs.
- Ozone remains a serious problem for human health as well as for vegetation and ecosystems. With a decreasing trend of ozone peak levels in NW-Europe the problem of high episodic levels tends to shift more to Southern Europe. The problem of stable or even rising average levels in NW-Europe remains important with regard to chronic effects from long-term exposure. Hemispheric background levels gain relevance, too.
- Eutrophication of waters and soil gains relative weight, given the still unsatisfying large gap between the expected level of protection and the ultimate goal of no exceedences of critical loads.
- Acidification is expected to shrink in terms of areas in excess of the critical loads. The issue of protecting also the most sensitive and vulnerable ecosystems and of ensuring recovery of damaged ecosystems remains on the agenda. The question is to what extent the need to tackle secondary PM will do the job to get rid of the remaining gap towards full protection.
- Heavy metals (HM) and persistent organic pollutants (POP) are being under consideration in the process of developing further air quality legislation on such substances. The focus of the required limit value in terms of air concentrations is mainly on the local scale. When considering depositions of these substances and accumulation in soils and water and the concern for human health and the environment then the problem takes on a transboundary dimension. Once ‘critical loads’ are derived for HMs and PoPs these could be incorporated into a multi-pollutant multi-effect strategy on acidification, eutrophication, ozone and PM.
- Urban air quality remains to be a factor of interest despite the envisaged improvement on SO_2, NO_2, CO and benzene levels. While it won’t be probably a driving factor for large-scale emission control policies the need to attain certain limit values might trigger measures in certain sectors, like transport, which are of interest in a larger context, too. In any case, illustration of the side benefit of measures of regional strategies on the urban scale (this includes also ozone and PM !) will reinforce their credibility and efficacy. On VOCs the question of speciation in relation to photochemistry and in with regard to possible health effects of single species may become important.

3. Challenges to the basis and design of the current approach

a) on the receptors: effects on humans and the environment

A general problem occurring in risk assessment is that no-effect or lowest-observed-effect levels on human health are increasingly difficult to specify. This concerns especially effects from exposure to PM. A simple reference to WHO guideline levels as the long-term objective will not be sufficient because such guideline may only consist of risk factors. This affects the current setting of a long-term objective and a related interim objective. We might need a substitute for the 'gap-closure' term unless we develop an appropriate way of defining a health risk level acceptable as a long-term goal for our policy.
A similar problem arises in relation to ozone effects to vegetation. Moving towards application of differentiated critical levels taking account of site- and plant specific factors (level II approach), in an integrated analysis improves the relation between pollutant levels and real effects. However, such differentiated critical levels become less appropriate as an air quality standard in EU legislation. Indicators for this purpose need to be less complex so as to remain easy to measure and to explain to the public and politicians. So, we have to find a way of transposing differentiated critical levels into a general air quality indicator while not completely loosing the correlation to effects.
The largest deficit of knowledge occurs in relation to effects of PM exposure. We need to identify what PM component is most relevant and which fraction of particles needs to be considered. Then we need to derive a suitable indication for which, ideally, sufficient information on sources, dispersion and pollution concentration is available or can be obtained within a reasonable time period.
Including HM in an effects based strategy requires developing 'critical loads' for HM deposition relating to toxicity to ecosystems and human health. The latter needs to take account of the pathway of these pollutants through soil, plants into the human body through the food chain.
As regards determination of critical loads for acidification we need a more robust and stronger quality assured process in order to reduce uncertainties affecting the final emission ceilings. This gains even higher relevance with decreasing excess of critical load and in the context of introducing recovery related factors into the approach.

b) on the sources: information on emissions, control potentials and costs

As mentioned above large gaps exist in our knowledge on PM emissions (including natural sources), particle formation (especially on organic aerosol), size distribution, source apportionment, constituents and control potential and costs. Even if the transboundary part of primary PM is not predominant PM emissions and inclusion of the primary PM into the analysis is inevitable for quantifying the health risk and monitoring progress of control strategies.

Ammonia is the next pollutant for which better data on country specific emissions, control measures and their efficiency and costs is urgently needed. We need to put more emphasis on ammonia control in the future not least because of its crucial role in the formation of secondary PM. So far the scarcity and uncertainty of information has been a major argument against further commitments to reduce ammonia emissions which stems almost entirely from agriculture It is crucial for enforcement of control policies to achieve a fair share of burden and costs for control measures between the sectors.

This is one reason why we need more precise and comprehensive information about contribution from sectors. Another argument is the principle of integration of environmental needs in other sectoral policy areas which have a high profile in EU policy development due to Article 6 of the Treaty. Consequently we need to provide preliminary emission control objectives for various sectors, e.g. agriculture, transport and energy, which enable adaptation of sectoral policies to the aim of sustainable development.
It goes without saying that proper reflection of the factors mentioned in section 1, like enlargement of the EU and the impact of Climate Change Policies, are crucial for any future cost-effectiveness analysis. With trading of greenhouse gas emissions as part of implementing the Kyoto commitment providing robust energy projections is becoming even more difficult. Also economic instruments might be more widely used and should be considered in the integrated assessment. In general it would be desirable if we could estimate the cost of policy options on a more realistic basis than on the pure "end-of-pipe' technology approach. Structural changes, like fuel switches, ought to be integrated to some extent, as well as the 'multiplier effect', that investment in one sector is income in another sector. All these factors lead to lower costs estimates as gained by the current methodology, which is an important aspect in the process of enforcing policy options.

c) on the source – receptor relationsships

Atmospheric dispersion models play a core role in the scientific analysis underpinning any emission control strategy. We need to cover all scales from hemispheric scale (ozone, PM, HM, POPs) to urban or even local (street canyon) scale. Interfaces are to be developed to integrated assessment models (IAM) on the regional and perhaps urban scale, which needs a compromise between the degree of complexity and the existing constraints in terms of computer time.
An important business to organise is proper model validation and model comparison, both between models and measured data and between different model simulations of emission reduction scenarios under defined boundary conditions. Emphasis should move away from episodic situations to full coverage of several years also for urban areas.

4. How could we manage to deal with them?

In order to co-ordinate all the various activities under one project framework the 'Clean Air for Europe' Programme is being established. A feasibility study is currently being conducted which obtains ideas from stakeholders for a proposal for the scope and structure of the program. The program will be launched with a kick-off conference beginning of 2001. The aim of the program is to identify (or confirm) key areas of requisite action, to provide the necessary tools and databases, to perform various analysis so as to allow consideration of various options of environmental objectives and associated emission control strategies. Finally, it should ensure appropriate stakeholder involvement during the whole process.
Not least because of the similarities of the approach underpinning the Gothenburg protocol and the NEC Directive one ought to exploit all opportunities for an efficient co-operation between the Community activities and those under the Conventions in the scientific investigations and analysis necessary within the review. Even without knowing the exact scope and structure of the Clean Air for Europe Programme a number of mutual benefits for the review of the Gothenburg protocol as well as for the implementation of the Programme can be expected.

Fields of particular strong collaboration between UN-ECE CLRTAP and the Commission might be

- effects (on ecosystems/vegetation and human health) and review/identification of appropriate indicators
- regional and hemispheric modelling
- emission inventories and projections
- integrated assessment modelling

Among the topics which are of interest here, a specific focus within the Clean Air for Europe Programme might be devoted to

- monitoring of air pollution and correlation with effects, especially concerning PM.
- Control measures and costs, especially on PM and ammonia
- Spill over from climate change policy
- Exploring the complementarity between the effect based strategy and existing/additional harmonised control measures based on BAT
- Compliance monitoring of air pollution and emissions
- Sector integration, i.e. taking into account developments in other policy areas (agriculture) and subsequently define preliminary emission control objectives for other sectors to be integrated into their policy

Topics for ongoing and future co-operation between North America and Europe:

- Effects, risk assessment and experience in setting air quality standards, in particular concerning PM and ozone
- Inter-continental interaction : hemispheric modelling of relevant pollutants and scenarios
- Development of control instruments in certain sectors: regulations on certain products, on- and off-road vehicle standards
- emissions of aircraft and ships, co-operation in international fora like the IMO and ICAO

4.4 What are the Needs for the Revisions of the Protocols and Strategies on Transboundary Air Pollution?

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Introduction

Effects on human health and the environment have always been important drivers for the LRTAP Convention. The Working Group on Effects and its International Co-operative Programmes were set up in the early days of the Convention to provide the necessary information to justify remedial action. However, it was only at the adoption of the 1988 Sophia Protocol for the control of NOx emissions that specific reference was made to the development of effects-based control measures based on critical loads. There was a clear intention that effects should become the direct drivers of abatement strategies in the future through the use of quantitative measures of damage – critical loads.

While the critical loads approach was recommended for revising measures for controlling NOx emissions, rapid progress was made scientifically. It was therefore possible to apply the approach to the second step for controlling sulphur emissions, the Oslo Protocol, in 1994. Subsequently, critical loads and critical levels were used for the 1999 Gothenburg Protocol to address acidification, eutrophication and ground level ozone.

While critical loads and levels have been important elements for the development of protocols, they have been utilised within the framework of integrated assessment models, making use of information on emissions, pollutant transport (from models), and abatement costs. This paper focuses on the issue of effects, with particular reference to critical loads and setting environmental targets for abatement strategies. It considers both the scientific aspects and the procedural framework for using the scientific output.

Driving effects for previous protocols

The Oslo Protocol was the first multi-national pollution control instrument based upon critical loads. It aimed at "further reductions" of sulphur emissions through consideration of their acidifying effects on soils and freshwaters. Critical loads maps were compiled based upon national data for either freshwaters, or soils, or both. Methods were applied nationally by National Focal Centres (NFCs), to selected national ecosystems using nationally selected methods from a Mapping Manual drawn up by the Task on Mapping (TFM). The calculated critical loads values were reported to the Co-ordination Centre for Effects (CCE) who collated a European database. Where no national submission was made, the CCE provided the necessary information from a European data set. Maps were adopted by the TFM (now the TF ICP Mapping) and the Working Group on Effects and used by the Integrated Assessment (IA) modelling groups reporting to the Task Force on Integrated Assessment Modelling.

The critical loads data were applied in a relatively simple way for the IA modelling scenarios. Data were aggregated to each 150km EMEP grid and a 5-percentile critical load calculated (that which, if achieved, would "protect" 95% of the ecosystem area within the grid). While this would provide full "protection", it was believed to define a suitably low target to be achieved for each grid. It should be noted, however, that the simple target ignores the variation of deposition and critical loads values throughout a grid, and this has been shown to under-estimate exceedances in general. Even so, the simple target was unachievable so a "gap closure approach" was adopted whereby deposition targets were defined on the basis of percentage reductions of deposition from "current" towards the 5-percentile.

To produce the critical loads for sulphur needed for IA modelling, the acidity critical loads were "partitioned" into sulphur and nitrogen components, based on "current" deposition estimates for sulphur and nitrogen for each grid. As the EMEP model was unable to account for base cation deposition, this was included in the critical loads for sulphur, which were then termed the "critical sulphur deposition". Estimates of base cation deposition were partitioned in a similar way to the acidity critical load, and the "sulphur base cation" added to the critical load for sulphur for each grid.

A problem arose where very low critical loads were encountered. Where these were less than the "unattributable" deposition (that not included in the "blame matrix" used in the IA models), critical loads were not achievable. For these grids, it was agreed that the 5-percentile critical sulphur deposition was set to the "unattributable" deposition.

The Gothenburg Protocol aimed at addressing the multiple effects occurring as a result of emissions of several of the major pollutants, e.g. sulphur, nitrogen (oxidized and reduced) and VOCs. Once again the critical loads approach was employed but for both acidification and eutrophication and also levels for ozone.

Once again there was a need for simplification. Data were again aggregated to 150km grids, but all data submitted were converted in a cumulative frequency distribution that provided target setting based upon protection of proportions of ecosystems exceeded. As both sulphur and nitrogen were included, there was no need for the false partitioning used in Oslo. Ozone was included in a simple way for crops and vegetation; level I applied to entire grid squares. Even this proved quite demanding for the IA modellers who used a computer pseudo-blame matrix to enable emission sources of NOx and VOCs to be linked to concentrations of ozone. Health effects for ozone were similarly simplified to the AOT60 values, which was controversial for some health experts.

Overall the modelling work for the Gothenburg Protocol was demanding and complex. However, it was still much simplified for those effects drivers included, and several important drivers were omitted. In view of the trade of between building in complexity and simplifying data and models, we might ask ourselves did we get it right for what is to be achieved under the Protocol?

Further development of previous driving effects

The scientific experts are generally well aware of the limitations of the methods used to quantify and apply the driving effects in IA modelling. They have, in the past, been forced to accept that unless methods and data can be generalised and applied across broad geographic regions, and are in a form useful for IA modelling, then they are of little use in the development of European wide abatement strategies. They have also seen the results of their labours summarised still further and applied in a simplistic fashion in the development of policy. Some scientists have found this unacceptable, others are prepared to sacrifice their detailed science to enable scientific principles to influence the development of policy. As a consequence those scientists involved with work under the Convention have generally accepted the current way of working as inevitable.

Unfortunately, the acceptance of the need to simplify and the lack of critical review probably gives much more credibility to the science, and more importantly the results of its application, than perhaps it deserves. Now that the Gothenburg Protocol has been adopted, it is a good time to consider the science in detail, identify the shortfalls and see how they may be accommodated in the future. A simple approach to this would be to consider the models and methods used and seek to make refinements or improve the input data. However, scientific ambition levels are higher, so current work includes:

Level II ozone. The major failings of level I predictions of ozone effects on plants are well recognised and becoming better understood. Work in this area has continued to make progress through work in ICP Vegetation, ICP Mapping and EMEP. Models are evolving to explain and predict some of the deviations from level I predictions, though it is not easy to see how these might be included in IA models in the future.

Dynamic modelling for acidity and eutrophication. The effects experts have long recognised the deficiencies of equilibrium models to predict effects and especially recovery. There are good dynamic models that effectively explain past and future trends where detailed calibration data are available. There is much emphasis now on extending this work in a simple way to broad areas of Europe to enable its use in abatement strategy development.

Economic assessment of existing driving effects. The TF Economic Aspects of Abatement Strategies has completed various economic assessments of effects in the past that have supported discussions on the development and adoption of Protocols. However, inclusion of economic aspects of effects in IA modelling has not been attempted. Health, building and materials and crops are obvious areas where this may be possible.

Health effects. There is a good deal of work reported from health experts on the effects of atmospheric pollutants. It is only relatively recently however that some agreement has been reached over parameters that may be used for IA modelling. Even so there is concern from health experts that better choices of parameters should be made in the future.

There are other aspects, more general in nature, that have yet to be addressed satisfactorily. The four items below are interrelated and highlight issues that are essentially insoluble but where further consideration and work is necessary:

Spatial scale – It is recognised that the EMEP grid size is, of necessity, very large. This has consequences in matching critical loads values to “local” deposition data. Even at the national scale this can cause problems in complex terrain. While the decreased size of EMEP grids to 50km will be a big improvement, the problem will persist. Statistical approaches have been devised that attempt to match deposition and critical loads data (Smith et al, 1995) but these may be complex to interpret. Results suggest that exceedances are much underestimated through the use of large grids.

Another scale issue results from the modelling area used by EMEP. There is increasing evidence that very long range transport may be significant in parts of Europe for ozone and other pollutants.

Data availability. It has been noted recently at the Copenhagen conference that lack of representative data may be the biggest problem in defining representative national critical loads. Very few countries have the necessary comprehensive data sets required to give representative maps of critical loads.

Uncertainties. Much has been talked about uncertainties but few studies have been made. From the few studies of uncertainties and from sensitivity analysis of the critical loads models, it would seem that relatively few parameters are responsible for most of the uncertainties. Parameters such as weathering rate are not only important for uncertainties, they are difficult to estimate and may be very dependent upon the representative data available, a problem as identified above.

Objective weighting of effects. Historically, areas of "ecosystems" have been used to quantify "damage", e.g. percentage of ecosystem area with critical loads exceeded. For the Gothenburg Protocol, excess deposition was also included through the accumulated exceedance approach. For modelling this showed "damage" as excess deposition multiplied by area, thus taking account of large excesses as well as large areas. While such approach may be considered to be objective, even the choice of area may be considered subjective. Does one unit, or one percentage, of area in one grid really equate to unity in another?

Furthermore, areas used are totally dependent upon those areas reported. For the Gothenburg Protocol, there was no systematic approach to reporting by most countries, few checks on ecosystem areas of different land cover types, and little transparency about what the critical loads maps and data really represented.

Consideration of additional driving effects

While a wide range of driving effects have been included in the Gothenburg Protocol, there are some obvious absentees. These are discussed briefly below with reference to their importance and the possibilities for future inclusion.

Materials and cultural heritage. This is an area where significant costs are associated with air pollution effects. However, it is often difficult to distinguish between local and long range transport effects. However, exposure response relationships are now better defined and work is being done to improve mapping stock at risk. Cultural heritage is a special issue which concerns many, but quantifying damage can be difficult.

Particulates effects on health. While some work was done on particulates for the Gothenburg Protocol discussions, This was as a "side-issue" and was not included in the optimisation work of the IA modellers. WHO see this as a high priority problem, though like materials and buildings above, some problems are local in nature.

Marine impacts. Marine impacts have been discussed from time to time at workshops, e.g. the Lokeborg nitrogen workshop, but now serious attempt has been made to include the effects resulting from deposition to seas.

Discussions and conclusions

There is a tendency, now that the multi-pollutant protocol is adopted, to look for new ways, both novel and maybe more realistic, for identifying future targets for IA emission control modelling. There are risks adopting this approach. These may be assessed by consideration of the options for the future.

It is anticipated that a review of the Gothenburg Protocol will take place within the next 3-4 years, when ratifications have sufficiently accumulated for it to enter in force. For this review we shall need to be able to answer such questions as:
Are countries on course in meeting their obligations?
Are the benefits from measures being realised?
Are they likely to be realised in the future?
Do we need to consider further measures through a revision of the existing Protocol?

The last three questions need to be addressed through consideration of effects and examination of status and trends. These could be done across a wide range of issues, many of which are not currently addressed effectively, e.g. the quality of the physical environment, and its impact on/consequences for, human health, natural resources, sustainable development, cultural and social environment, aesthetic and recreational value of the habitat, and on local/national economy.

There are a number of approaches that may be used for review of effects, ranging from the status quo to the visionary, but a link to effects drivers would provide the link to past decision making and links to alternative drivers for possible future revisions of Protocols. More specifically, one or more of the following approaches may be applied:

a) Use the existing critical loads database and compare exceedances in 1999 with those estimated for depositions and ozone concentrations in 2004.
b) Use an updated critical loads database (i.e. updated data and calculations) for the above comparison.
c) Use a revised critical loads database (i.e. upgraded and revised models and data) for the comparisons.
d) Consider "realistic" approaches (e.g. use monitoring data, field data and models) for quantifying "initial" status and observed change to assess improvements.
e) Use alternative air quality standards or guidelines to assess benefits.
f) Take into account uncertainties in assessing status and change.
g) Use dynamic models to assess benefits over long time scales.
h) Use risk assessment approaches to evaluate possible damage taking into account uncertainties and time.

There is a good argument for several, or perhaps all, of these including the simple approaches of a) or b). While we need to take advantage of the progress of science, we should not reject the original simple approach. First, because many will ask for comparison with anything that is more progressive. Second, there are some changes that are inevitable, e.g. EMEP is changing the scale of its modelling, some countries will argue strongly to update their databases. It is therefore important to have some comparison with what was agreed under the protocol to provide the policy maker with a "standard" even if this has been superseded scientifically. Indeed, an in-depth evaluation of the old "standard" may provide a good basis for "selling" new ideas to the policy maker.

In practice we shall need to focus on particular areas where it is possible to make progress with the resources available, and where the pay-offs are likely to be significant and useful. This means setting priorities in particular areas and drawing up timetables that are realistic and achievable. For this, consideration needs to be given to the drivers that have been used in the past, the drivers that were omitted from the Gothenburg Protocol, and the drivers which could be included in some form in the future. This will help determine priorities for the approaches listed above.

Perhaps one of the key issues that will determine priority setting is if there is continuing political interest/support for implementation and further development of the Convention, or if we have to generate new interest in/increase attraction for supporting work under the Convention. The answer to this will determine much of our future strategy.

4.5 Future Needs within the Field of Transboundary Air Pollution

Scientific Challenges

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Introduction

Science has been an important factor for the development of the strategies and protocols for the transboundary air pollution; probably more important than for any other environmental problem. Continually, since the problem was discovered more than 30 years ago, scientific observations, experiments and model approaches have been closely linked to the development of policy actions.

Today, when the Gothenburg protocol is signed and the EU ceiling directive is proceeding, the important question is if there is a need for better scientific understanding in the future when the protocols and strategies are to be revised.

This presentation will focus on some areas where there might be needs for improved scientific knowledge. It will also discuss the problem of keeping the scientific research level to support future strategies.

Concepts and criteria were developed 10 years ago

The concepts and assumptions behind the recently signed Gothenburg protocol were developed more than 10 years ago. Most of the scientific research forming the main basis was done around 1990 and has only to a limited degree been questioned during the last years. There have been a number of improvements in models and details but the main concepts were all set around 1990.

Since the revision of the Gothenburg protocol is not expected to take place until around 2004-2005, we will have a unique opportunity to update our knowledge and to re-evaluate the concepts and methods. It will also be an opportunity to encourage the scientific community to come up with new ideas and concepts better reflecting the present environmental situation and knowledge but also reflecting the changes in environmental policies and views over these years.

Environmental science has as one of its tasks to support policy decisions and has been doing so within the field of transboundary air pollution for a long time. Science has also the role of questioning and critical assessment. There has been, however, little of this during the last 10 years. During the next few years we probably need to do some work in this area in order to make sure that our science and model approaches are sound and defendable.

1988: A concept of reducing pollution --- 2000: A concept of sustainable development?

When the first ideas on the effect-oriented strategies based on critical loads and levels were presented, the air pollution situation in Europe was severe and the main objective of a protocol was to save Europe from a threatening air pollution catastrophe. The idea of sustainable development was just presented but it was far from forming a basis for an air pollution strategy. Today, the sustainable development concept is influencing the views on ecosystems and may therefore change our views on critical loads and levels and other environmental targets. The critical loads concept for soil acidification is e.g. accepting an ongoing acidification and leaching of aluminium as long as biological systems are not damaged. But with a sustainable development concept, the long-term stability of soils and ecosystems becomes a basis for establishing effect criteria. A review of the critical loads and levels based on the concepts of sustainable ecosystems may be one interesting scientific task.

A green Europe in 2010?

The present strategies will, according to the model calculations, turn an almost red Europe in 1990 to a much greener one in 2010. For acidification this is particularly true, since, based on the recent Gothenburg protocol, ecosystems with an exceedance of critical loads in Europe will be reduced from approx. 93000 ha in 1990 to approx. 15000 ha in 2010 or a reduction of about 84%. If looking at the total excess load expressed in equivalents per year, the improvements become even larger since the total excess load will be reduced by approx. 96%.

If we still will use the same strategy for further reductions, fewer and fewer ecosystems will show exceedances of the critical loads and levels. Consequently, the excess deposition to these ecosystems will be less and less and it will certainly be more and more difficult to motivate further reductions. But further reductions will not only be beneficial for the remaining areas. They will also be of benefit for all damaged ecosystems, since they will enhance the recovery of damaged ecosystems. Model calculations based on field experiments show that the recovery will depend on how far below the critical loads deposition is reduced. The possibility of improving the critical loads concept to include benefits of reductions below the critical loads may be an important scientific task which may fit into the strategies of tomorrow. In fact, this improvement is partly under way as it was brought up as an issue at the Critical loads workshop in Copenhagen and will be the central focus for a new workshop to be held in the autumn.

How far is it beneficial to reduce the deposition of nitrogen compounds?

It is well known that nitrogen is both a pollutant threatening ecosystems and a necessary nutrient. Recent observations also indicate that nitrogen will increase carbon immobilisation in ecosystems. One important question is therefore if it is possible to find an optimal input of nitrogen which at the same time reduces acidification and eutrophication effects and improves carbon sequestration.

Including land use in the environmental strategies

One of the measures to reduce emissions of greenhouse gases is to increase the use of biofuel. This may lead to an increased extraction of wood (branches, tops, etc.) from forests. But the wood contains alkaline compounds such as potassium, magnesium and calcium and the forest soils will thus be further acidified by an increased wood extraction. The understanding of the links between the acidification caused by atmospheric pollution and the acidification caused by wood extraction need to be further investigated and considered in the future strategies.

Particulates

Particulates were not included in the Gothenburg Protocol but are probably the most important driving force for the reduction of air pollution in Europe today. The basic knowledge on particles is still to a large extent lacking. This is true for

- emissions, including both direct emissions and those gases being of importance for atmospheric particle formation,
- atmospheric transport and conversion processes
- exposure modelling and
- human health effects

The intense research in both North America and Europe will probably generate data making it possible to include particles in the future revisions of protocols.

Are there alternative science-based approaches to the effect-oriented cost-effective processes used in the recent Gothenburg Protocol?

The integrated assessment model approach used in the Gothenburg protocol is not the only effect-based solution for a cost-effective strategy for regional air pollution in Europe. There are other alternatives, for example focusing more on the contribution to effects from sources instead of looking at contributions to receptors. Within other environmental control areas e.g. in Life Cycle Management the source-oriented approach is of particular interest. During the next 2-3 years it would be interesting to test other approaches and compare advantages and disadvantages.

Robustness and uncertainties

Uncertainties are often brought up in connection with the use of integrated assessment models. Uncertainties are however seldom discussed in connection with the outcome of a protocol and how robust different calculations are with respect to underlying uncertainties. It is worth noting that uncertainties may influence the outcome of a protocol in essentially three ways. They may

1. raise doubts about the overall control needs
2. give incorrect priorities between countries and sectors
3. give incorrect priorities between substances (S or N control for acidification, NOx or NH_3 control for eutrophication, NOx or VOC control for ozone)

The first type of uncertainties is mainly connected to the setting and mapping of critical loads and other environmental targets, while the other two are associated with all factors included in the integrated assessment modelling (emissions, control costs, source-receptor and dose effect relationships, grid sizes etc.). Uncertainty analyses have so far not been done with respect to the above mentioned factors but will probably be very valuable in the development of future control strategies.

International scientific collaboration

Regional air pollution research is today given less financial support compared to the situation 10 years ago. The improved air quality and signed agreements give the impression that the problem is on its way to be solved. The financial support may due to this be reduced even further and may threaten the necessary support for the next strategy. But the needs for accurate scientific data will rather increase when we are approaching the critical loads and levels or other threshold values, especially if we continue with effect-oriented, cost-effective strategies.

With shrinking research budgets in most countries, the need for collaboration will therefore increase. Only a few countries will probably be able to keep a top scientific level in all the areas of interest with respect to regional air pollution. The question is therefore if we can find ways to improve and facilitate the international collaboration and also to transfer results of importance in an international context instead of a national.

The work within the CLRTAP bodies will probably be of crucial importance for the scientific collaboration. The different groups under the Working Group on Effects and EMEP have a particular responsibility to encourage scientific research and to evaluate and make agreements on concepts, criteria and methods on which the further strategies can be built. Regular workshops under the CLRTAP umbrella are probably one way for keeping and developing scientific collaboration.

But there are probably needs for scientific collaboration in addition to the CLRTAP. For atmospheric processes, EURTRAC has for more than 10 years formed an alternative platform and been important for a general increase in knowledge. For effects a similar European program is missing. Will it be possible to establish an effect-oriented EUROTRAC?

4.6 Tools for Cost-effective Control Strategies

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Introduction

For the first time, the agreement on the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level ozone considered the control of air pollution as a multi-pollutant/multi-effect task. Building on an 'effect-based' approach, national emission ceilings should guarantee that common environmental objectives will also be achieved for transboundary pollutants. Implicitly, while acknowledging minimum and internationally uniform source-specific BAT requirements, flexibility is left to the parties on how certain emission reduction targets could be best implemented. This opens the door for economic instruments (fuel taxes, road pricing, fiscal incentives, etc.) and for complementary measures on a local scale.

The cost-effectiveness analysis

The 'cost-effectiveness' principle emerged as the driving rationale for deciding about the appropriate stringency of emission controls. This principle aims at the least-cost solution to achieve given environmental air quality criteria and thereby guarantees that all proposed emission reductions will be justified by actual environmental improvements. The cost-effectiveness principle implies that more stringent measures are required in ecologically sensitive zones while avoiding over-controls in areas where the environmental objectives are already met, possibly resulting in an uneven distribution of reduction costs among the European countries.

It is important to mention that the cost-effectiveness concept is fundamentally different from a cost-benefit analysis. Under the cost-effectiveness concept, the extent of emission reductions is driven by exogenously specified targets for environmental quality. Under a cost-benefit approach the appropriate stringency of emission controls would be determined by the balance between emission control costs and monetized environmental benefits.

To support the quantification of emission reduction obligations, the negotiations on the protocol relied on scenario analysis conducted with the Regional Air Pollution Information and Simulation (RAINS) model. The RAINS model, developed and maintained by the International Institute for Applied Systems Analysis (IIASA), is a tool for an integrated assessment of multi-pollutant emission control strategies addressing multiple environmental effects including ground-level ozone, acidification and eutrophication. The model combines information on the sources of emissions (e.g., economic development, the present and future structure of emission sources, the potential and costs for controlling emissions) with scientific information about the dispersion of pollutants in the atmosphere including the ozone formation processes. It compares the resulting regional air quality with various indicators of stock at risk (e.g., population, critical loads and critical levels for vegetation, etc.), see Figure 1. An optimisation feature makes it possible to identify the least-cost combination of emission control measures for individual pollutants (SO_2, NO_x, VOC, NH_3) in the various economic sectors in order to achieve exogenously determined constraints on pollutant deposition and/or concentrations (Schöpp *et al.*, 1999).

The RAINS model was used to explore the implications of a range of environmental objectives for ground-level ozone and acidification at various ambition levels (Tuinstra *et al.,* 1999). With the optimisation feature of the RAINS model it became possible to identify cost-effective emission controls to meet the specified environmental policy targets.

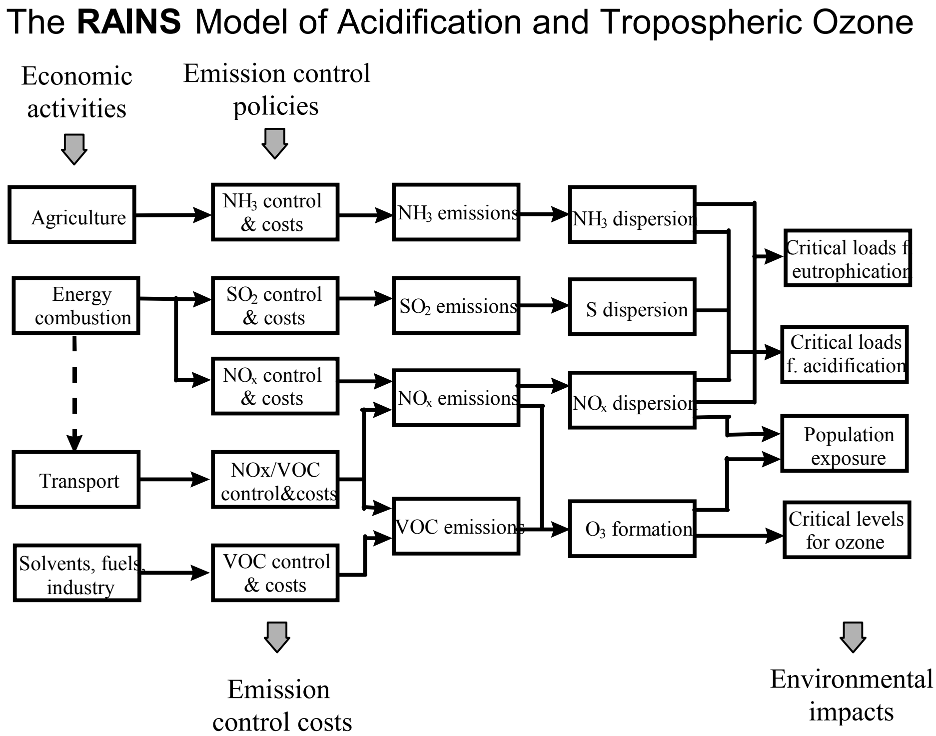

Figure 1: The structure of the RAINS model

Future challenges

To respond to the policy question anticipated for the forthcoming review, the modeling tools need to be refined in several aspects. First, threats to human health posed by fine particulate matter will be a major subject of concern, and quantitative relationships between changes in (primary and secondary aerosol) emissions and resulting (health) impacts are indispensable for a cost-effectiveness analysis. As a second area, the effect-based concept must be refined to more accurately address real impacts of pollution, e.g., on human health, instead of purely using concentrations of pollutants in the ambient air as the endpoints of the analysis.

Additional pollutants: Fine particulate matter

Fine particulate matter receives growing attention as a major threat to human health. While the exact mechanisms of how fine particles damage human health are not fully explored yet, it is clear that fine particles found in ambient air originate from a variety of precursor emissions:

- Some activities (fuel combustion, industrial processes, surface corrosion, etc.) release small particles directly into the atmosphere.
- (Organic) aerosols are a secondary product of photochemical processes in the atmosphere, which are closely related to ozone formation and its precursor emissions.
- Sulfate and nitrate aerosols are formed from sulfur and nitrogen emissions, with the availability of ammonia as a determining factor.

Cost-effective strategies to reduce ambient levels of fine particles have to balance the contributions of all three pathways and to determine the optimal emission controls accordingly. They need to consider the future evolution of the various precursor emissions due to emission control legislation taken for other purposes (e.g., to control ground-level ozone or acidification). And they have to provide for the possibility that the relative importance of these three formation mechanisms may vary over Europe, and that a cost-effective response for Mediterranean countries might be different from a strategy tailored to the situation in Scandinavia.

Most of the basic knowledge for quantifying the formation of fine particles is already available, and integration with today's cost-effectiveness tools dealing with acidification and ground-level ozone seems feasible (Table 1), so that much of the existing information and databases could be utilised. The major challenge will be to construct reliable databases characterising the situation in the various parts of Europe and to systematically assess the uncertainties inherent to the calculation routines.

	SO_2	NO_x	NH_3	VOC	Primary PM emissions
Acidification	√	√	√		
Eutrophication		√	√		
Ground-level ozone		√		√	
Health damage due to fine particles	√ via secondary aerosols	√	√	√	√

Table 1: Air quality management as a multi-pollutant, multi-effect problem

Extending the scale: Integration with urban and indoor pollution

While the presently available instruments for a European cost-effectiveness analysis deal with the regional scale and have only a relatively coarse spatial resolution, health impacts are determined by the actual exposure of individuals to the various pollutants. For improving the cost-effectiveness of strategies it will be crucial to explicitly address the various scales at which the different types of pollution occur. In the ideal case an assessment should identify the characteristic patterns at which people are exposed to these regimes and search for cost-effective solutions to improve regional background levels of pollution, the typical concentrations of pollutants in ambient urban air and in street canyons, and indoor pollution.

Shedding light on these aspects is a formidable task for science. It will require accurate modeling of the relevant (often long-term) concentrations of pollutants at different spatial scales and, perhaps even more important, of how pollution at the different scales interacts with each other. It will also require careful analysis of pollution regimes to characterize representative situations that make the largest contribution to personal exposure.

Ultimately, the question will be at which level certain emission control measures are best taken - as action at the international level, as national action, at the urban scale or even by modifying the personal life styles of sensitive individuals. Answers to these questions need to consider not only the biological and physical factors, but they also have to integrate economic, technical and legal aspects, for instance possible distortions to competition and implications for the free trade of goods within the common market.

It must be expected that science will not be able to provide full answers to all relevant questions within the given time horizon. However, while clearly recognising the remaining gaps in knowledge, science can help to identify a robust set of measures that would be most prudent to include in the next policy step to achieve clean air for Europe.

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5. Background Papers

5.1 Requirements for Input Data into International Activities Supporting the Development of Emission Reduction Strategies in the Framework of Long-range Transboundary Air Pollution

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1. Background

In the last years the effects of long-range transboundary air pollution have lead to increased international co-operation, e.g. through Protocols under the UN/ECE Convention on Long-range Transboundary Air Pollution. Strategies to abate acidification, eutrophication and tropospheric ozone formation are currently elaborated under the UN/ECE (cf. the Protocol to Abate Acidification, Eutrophication and Tropospheric Ozone, so-called “Gothenburg Protocol”) and the European Union (Directive on National Emission Ceilings). For the preparation of both regulations, the development of strategies is based on the concept of critical loads/ levels. In this concept, the integrated assessment model RAINS [RAINS] is used for the determination of national emission reduction rates for the pollutants SO_2, NO_x, VOC and NH_3 for each country. The determined national emission reduction rates are highly dependent on the corresponding national cost functions (total national costs for emission reduction for specified emission reduction targets), which are determined endogenously within the RAINS model.

The elaboration of cost functions requires techno-economic parameters of emission sources and applicable emission reduction measures, e.g. emission factors, emission reduction efficiencies, investments, operating costs. Besides these technology-related data, country-specific information on sectoral activities, on the structure of the emission sources and associated emission reduction measures already in place within the sectors is necessary, i.e. data on installed capacities of different technologies, implementation rates of emission reduction measures, etc.

Techno-economic data and, if necessary, country-specific data, on emission sources and associated emission reduction measures play a fundamental role not only for the elaboration of cost functions, but also for further applications, in particular:

- the determination of “best available techniques” (guidance document of the UN/ECE protocols, application of the IPPC-Directive of the EU),
- the elaboration of emission inventories and projections in the framework of reporting obligations (e.g. to EMEP, to the Commission of the EU),
- the cost-benefit analysis of emission reduction measures and environmental regulations (emission limit values, etc.),

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- the organisation of information exchange in the framework of transfer of technologies between countries.

2. Requirements to input data

For the collection, administration and exchange of input data to the above mentioned activities, the following requirements have to be considered:

- comparability and consistency of results between different applications and different countries: harmonisation of e.g. basic assumptions and derivation procedures of input data
- definition and setting of a common aggregation level
- transparency, in order to increase the acceptance of work and results by industrials and associations of industrials of involved countries as well as political decision makers
- continuous update and improvement of data (technological progress, operationnal experience)
- consideration of synergy effects between the various pollutants, e.g. simultaneous consideration of SO_2 and CO_2 emissions (cf. Background Paper on the impact of structural measures and a combined emission reduction on emission reduction strategies)

2.1 Consistency

In the past technology-related data was required in the framework of the preparation of the UN/ECE Protocols. This data was prepared by Task Forces or Expert Groups that were linked to the Working Group on Abatement Techniques, and aimed primarily at the preparation of the Technical Annexes (best available techniques, emission limit values) of the Protocol and the corresponding Background Documents. This data can be used for the elaboration of emission inventories and projections and the determination of cost functions within integrated assessment models, but the transfer was not satisfying. For the elaboration of national cost functions, emission inventories are needed for the base year. On the other side, models dedicated to the elaboration of emission projections could use the results of models for the determination of cost functions, e.g. the development of technology distribution and implementation rates of emission reduction options within a given planning horizon. Furthermore, since emission inventories are often needed within very short time periods, preliminary projected emission data may be necessary in order to fill gaps induced by lack of available data. As emission projections may be needed to support emission inventories, a common approach and common sets of input data for inventories and projections are required.

However, there is still divergence between the used approach and input data sets of emission inventories and projections on one hand and those of national cost function on the other side, e.g. consideration of different aggregation levels; the use of synergies remains thus difficult. If the mentioned applications, also e. g. determination of best available techniques, uses different approaches and input data with regard to e.g. sector classification, aggregation level, cost definitions, inconsistencies between results from these different activities may arise, leading in some cases to contradictions.

In order to avoid duplication of work and ensure comparability and consistency of results between different applications and different countries, input data, i.e. basic data, derivation procedures, assumptions, should be harmonised. Furthermore, if all the sectors are analysed via the same homogeneous approach, results can be compared. Especially concerning country-specific data on the structure of emission sources and applicable control options that are necessary i.a. for the elaboration of cost functions and emission projections, the reliability of the results strongly influences the acceptance of these results by countries and industrial associations. If consistency is ensured, the determination of cost effective emission reduction measures for the elaboration of national functions could be based on defined "best available techniques" (BAT) and/or on set limit values on installation level. If the determination of BAT, the setting of limit values and the elaboration of national cost functions base on the same techno-economic data sets, the consistency is ensured and the comparability between results guaranteed. A fundamental element for consistency is the choice of a common adequate aggregation level.

2.2 Adequate aggregation level

In the framework of international reporting obligations, emission inventories and projections are in most cases requested on sectoral level (e.g. printing industry, petroleum products processing), or even on installation level, e.g. reporting in the framework of the IPPC-Directive. The determination of "best available techniques" (BAT), both in the framework of the elaboration of Technical Annexes to UN/ECE protocols and the application of the IPPC-Directive of the EU, is performed on installation resp. process level. For different requirements (e.g. VOC-Directive, Technical Annexes of UN/ECE protocols), emission limit values as well are set on installation level. The chosen level of aggregation allows for a direct comparison of this data with parameters of "real" installations, which eases the dialog with concerned industrials and associations of professionals.

2.3 Transparency

In order to increase the acceptance of strategies based on results of e.g. national cost functions, the possibility of verification resp. validation of used input data should be given to branch experts, industrials and associations of professionals. Verification procedures can be supported by documentation of basic data and data sources, specification of hypotheses and derivation procedures used for the determination of the techno-economic data on installation resp. process level. Furthermore, on European Union level, detailed reporting and documentation of methodologies, assumptions and basic data used for the elaboration of emission inventories and projections in the framework of reporting obligations (e.g. LCP-Directive, NEC-Directive) can be requested by the Commission. For these purposes, a transparent and homogeneous documentation is required as well.

2.4 Continuity

Since in the past the lifetime of the Task Forces or Expert Groups generally coincided with the preparation time of a given protocol, the continuity of work was not ensured. Owing to the very short delays awarded to the preparation of Protocols, the determination of national cost functions was performed centrally for all the countries; since a certain number of countries were unable to deliver the required country-specific data within such short time frames, a supplementary task of the modellers was also dedicated to data collection.

Revision procedures of UN/ECE protocols and Directives of the European Union could be facilitated, if the necessary techno-economic and country-specific data would be available when starting the revision process. The work of the modellers, who could concentrate on modelling activities, could thus be eased. For this purpose, a continuous update and improvement of data should be ensured.

3. Preparation of the Gothenburg Protocol

Considerable progress has been made concerning the techno-economic characterisation of technologies within the work of the Task Forces on the Assessment of Abatement Options/techniques for Volatile Organic Compounds and Nitrogen Oxides from Stationary Sources, that were in charge of the preparation of the Background Documents and the Technical Annexes of the Gothenburg Protocol [UN/ECE 1999a, 1999b, 1999c, 1999d]. In this context the “Reference Installation Approach” was developed, enabling for a consistent, reliable and transparent analysis – at an adequate aggregation level – of the techno-economic parameters of production processes and associated emission reduction measures. These technology-related parameters are documented in so called “data sheets” whose structure is homogeneous and compatible with the CORINAIR nomenclature for all sectors; an “explanatory part” is attached to each data sheet for documentation of basic data, assumptions and calculation procedures. The database includes all stationary sources of VOC and NO_x, whose contribution to total emissions and emission reduction potential are significant. The data prepared by the mentioned Task Forces delivered basic information for the determination of best available techniques and emission limit values for VOC and NO_x, as well as for the corresponding Annexes and Guidance Documents to the Gothenburg Protocol. The data on VOC have also feeded the database of the integrated assessment model RAINS for the determination of national cost functions.

On the aggregation level of reference installations, technology-related data (e.g. emission factors) mainly depend on the "intrinsic" properties of techniques and are only weakly country and time dependant. The reference installations and the corresponding emission reduction options can be used to characterise the country specific emission source structure of a given country. The use of the same (default) set of reference installations with the same characteristics ensures the consistency and comparability of the data between different countries. Of course this does not preclude some adjustments of the emission factors and abatement efficiencies to account for country particularities e.g. solvent content in coatings for VOC emissions. Furthermore, the chosen level of aggregation and the documentation allow for a direct comparison of this data with parameters of “real” installations, which eases the dialog with concerned industrials and associations of professionals as well as political decision makers.

The reference installation approach and the data sheet concept are applicable to all sources and all pollutants, and are particularly adapted for the characterisation of measures reducing simultaneously several pollutants (multi-pollutant approach). Taking into consideration the evolution of the needs of the users, the now existing databases on VOC and NO_x could be enlarged to further pollutants (e.g. SO_2, heavy metals, persistent organic compounds, particulate matter) and to further sources (mobile sources). If necessary a common definition of reference installations could be used for measures reducing simultaneously several pollutants. In the light of revision procedures under the UN/ECE and the EU, techno-economic data are required. The reference installation approach and the data sheet concept could serve as methodological basis.

4. Revision procedures and further needs

The protection levels of the ecosystems that are fixed in the draft Gothenburg Protocol and in the draft EU Directive on National Emission Ceilings correspond to intermediate goals, which will be tightened in further steps, aiming at a total preservation of all the ecosystems and the respect of threshold values for exposition relative to health protection. In the revision procedures the Guidance Documents will be reviewed and the emission limit values updated in order to take into consideration technological progress. The modelling activities which will have to be performed in the framework of the foreseen revisions will become more complex, since the simulations show that it will not be possible to reach these objectives with only technical measures. Moreover, as in the past the mandates of the Task Forces often dealt with one pollutant only (SO_2, NO_x, VOC, etc.), the applied concepts did not take enough into account the synergy effects between the reduction strategies for different pollutants (e.g. simultaneous consideration of SO_2 and CO_2 emissions). Also the consideration of structural measures, dynamic aspects and synergy effects between the abatement measures of the different pollutants will gain more and more importance, thus stricter requirements will be needed not only for modelling activities, but also for the input data.

At the last Session of the Executive Body, an Ad Hoc Working Group on Abatement Options and Cost Calculations under the Working Group on Strategies and Review, as proposed in [UN/ECE 1999e], has been created, which will contribute to facilitate the work of the Task Force on Integrated Assessment Modelling.

5. Conclusions and Recommendations

1. In order to ensure consistency and transparency of input data and continuity of work, and in the light of the short time frames for revisions of environmental regulations, a harmonised collection, administration and exchange of techno-economic (technology-related) and country specific data is needed. To feed this data into diverse activities, a unified data format would show significant benefits for the work of the modellers, if appropriate interfaces to Integrated Assesment Models would be provided. Data verification should be performed by national experts.
2. A first step in that sense is the installation of an Ad Hoc Working Group on Abatement Options and Cost Calculations under the Working Group on Strategies and Review, decided at the last Session of the Executive Body. This Working Group will contribute to facilitate the work of the Task Force on Integrated Assessment Modelling.
3. In order to guarantee for continuity, a central organisation should support the tasks of this Working Group, like

- continuously update and improve techno-economic databases,
- ensure transparent documentation of input data to the different activities,
- support the revision procedures under the UN/ECE and the EU,
- improve communication and co-operation between national experts involved in activities, e.g. emission inventories and projections and integrated assessment modelling, and finally

- allow for a more efficient use of databases by the various activities and avoid duplication of work.

4. With regard to the working programmes of the UN/ECE and EU DG XI (Clean Air For Europe Programme), an extension of the existing databases on VOC and NO_x to further pollutants (e.g. SO_2, heavy metals, persistent organic compounds, particulate matter) and to further sources (mobile sources) should be performed. For this purpose, the techno-economic analysis of emission sources and associated emission control measures could be based on the reference installation approach; documentation could be performed via data sheets.

5. In order to facilitate the work of the modellers, who could concentrate on modelling activities, the techno-economic and country-specific data, necessary for the revision procedures under the UN/ECE and the CAFE Programme of the EU, should be available when starting the revision process. A continuous update and improvement of data should thus be ensured.

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5.2 Impacts of Structural Measures and a Combined Control of Emissions on Reduction Strategies

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1. Background

As a decision basis for international commitments on the reduction of long-range transboundary air pollution, recommendations on how to avoid harmful effects in a cost-effective way are required. In addition to information on environmental impacts (critical loads/levels) and the atmospheric processes (transport, conversion and deposition), information on reduction measures and costs (development of emissions, reduction measures, related costs and national cost curves) are a necessary input for the development of cost-efficient emission reduction strategies. For the development of national cost curves for an emission reduction of SO_2, NO_x and VOC, it is necessary to integrate not only end-of-pipe measures, but also energy conservation as well as input and technology substitution options. This is due to the fact that further the potential of cost effective end of pipe measures is limited in some European countries like France or Germany. Furthermore, the effects of combined emission reduction strategies (the so-called multi-pollutant approach) have to be analysed. Besides emission reduction options for SO_2, NO_x and VOC, such an approach has to include greenhouse gas emission reduction options, because most of these options - like energy efficiency increase or the fuel substitution of coal or oil by gas - have a significant influence on the development of other emissions.

The objectives of this paper are the discussion of selected methodological aspects of the development of national emission reduction cost curves and the presentation of how to handle these aspects with linear energy and material flow optimisation models. Furthermore, selected results for national emission reduction strategies will be presented.

2. Description of optimising energy and material flow models

2.1 PERSEUS

The program package PERSEUS (Program Package for Emission Reduction Strategies in Energy Use and Supply) [1] belongs to the class of bottom-up models[4]. From a system-theoretical point of view, the elements of the system represented by the models are energy conversion technologies transforming energy, material and emissions. The elements are interconnected by energy, material and emission flows, thus making it possible to consider the interdependencies between individual measures and to elaborate consistent, national reduction strategies (see 3.1). The national module of the PERSEUS

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[4] The models respectively modules of the program family are based on the EFOM-ENV model of the EU [3], the different program modules are necessary to be able to derive recommendations for different kinds of problems.

models aims at deriving strategic recommendations for the future structure of the energy system. To achieve this aim, a system optimisation is performed. The optimisation criterion is usually the minimisation of the discounted expenditure (using the net present value method) to satisfy an exogenously given demand taking into account different restrictions (e.g. emission restrictions). The optimisation variables are the energy and material flows as well as the energetic capacities to be newly installed.

Energy conversion technologies in different sectors - industry, transport, tertiary - as well as emission reduction technologies and energy flows are characterised by technical[5], economic[6] and environmental[7] parameters. The PERSEUS model employs a dynamic linear programming approach and has been implemented using the algebraic modelling language GAMS (General Algebraic Modelling System) developed for the World Bank [4]. PERSEUS determines the "optimal" structure of the future energy system for a typical time horizon between 15 and 40 years. Restrictions can be imposed on emissions resulting from electricity and heat generation as well as from distribution of energy carriers (e. g. natural gas).

To facilitate the use within different countries, the user-friendliness of the model had to be improved. Therefore, a data management system has been developed to reduce the need for specialised training of users. It is based on Microsoft Access and contains all relevant data on the structure of the energy system as well as on the characteristics of existing and new energy conversion technologies. All data records can be edited within user-friendly input forms. In addition, to facilitate maintenance and modification of large, periodical data sets using spreadsheets, a link to Microsoft Excel has been programmed. The data management system consists of two databases; the first one contains the complete functionality of the system – i. e. forms, queries and code – while the actual data is stored in the second one. In addition to being able to work on different "data"-databases with one "system"-database, this structure facilitates the maintenance and upgrading of the system as existing data-databases can still be used even if enhancements and modifications to the whole system necessitate the implementation of a new version of the system-database.

For the analysis of the model results, a module which automates the generation of aggregated tables and charts and provides a link to the utility's internal accounting has been implemented using Microsoft Excel. The structure of the complete PERSEUS system is shown in figure 1.

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[5] E. g. efficiency, lifetime.

[6] E. g. investment, fixed and variable expenditures.

[7] E. g. emission factors for SO_2, NO_x, CO_2.

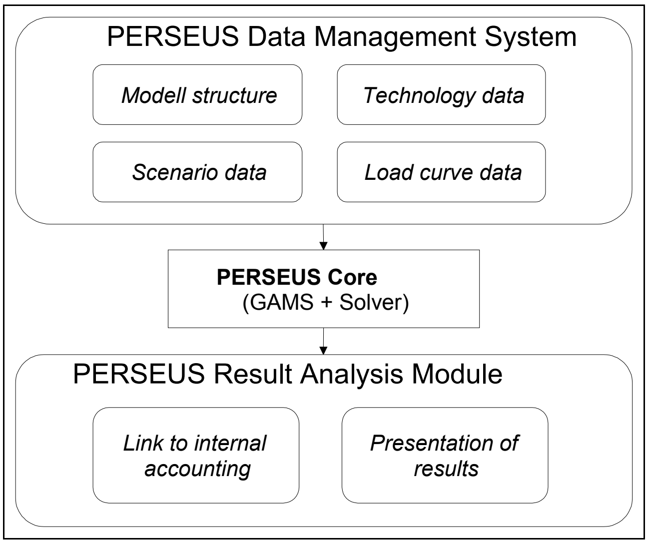

Figure 1: Modular structure of the PERSEUS model

Considerable work supported by the European Union has been carried out in order to facilitate the transfer of energy-economy-environment models to Central and Eastern European Countries (CEECs) [5]. A reference version of PERSEUS is available including all relevant energy conversion processes and abatement options, thus facilitating an adequate model transfer to and model application in countries with economies in transition. This model has been adjusted for many EU and CEECs countries and can be used, inter alia, for the elaboration of cost functions. The latest version of the PERSEUS reference model which integrates the emission reduction options for NO_x and the corresponding techno-economic data developed in the Task Force on Abatement Options/Techniques for NO_x has been recently implemented for France and used to calculate NO_x cost functions for scenarios regarding the period for the implementation of emission reduction obligations, the lifetime of nuclear plants, the value of the real interest rate and constraints on the stabilisation of CO_2 emissions [7].

2.2 ARGUS

The dynamic mass-flow optimisation model ARGUS (Allocation module for a computer aided generation of environmental strategies for emissions) belongs, as PERSEUS, to the class of bottom-up models. It is based on a detailed representation of all relevant stationary VOC emission sources and the corresponding applicable emission reduction options. Within the model, production processes and abatement techniques for VOC emissions with related input and output flows are represented for about 40 relevant source categories. With regard to VOC emissions, different categories of measures are considered: substitution of input material (e. g. switch from solvent based coating systems to water based coating systems) or modification of the production process (e. g. increased application efficiency of coatings on surfaces) and end-of-pipe measures (e. g. thermal incineration of solvents in the waste gas). In total, the ARGUS model considers about 2000 different processes and 1500 different flows. Emission sources and abatement options are described in terms of “reference installations” defined by the UN/ECE Task Forces on Abatement Options/Techniques for VOC and NO_x [9]. “Reference installations” represent defined categories of installations in order to handle the huge number of individual sources. Individual installations are assigned to defined categories concerning their characteristics of reduction efficiency and costs for a given

VOC abatement measure. Figure 2 shows the main data in- and output of the mass-flow optimisation model ARGUS.

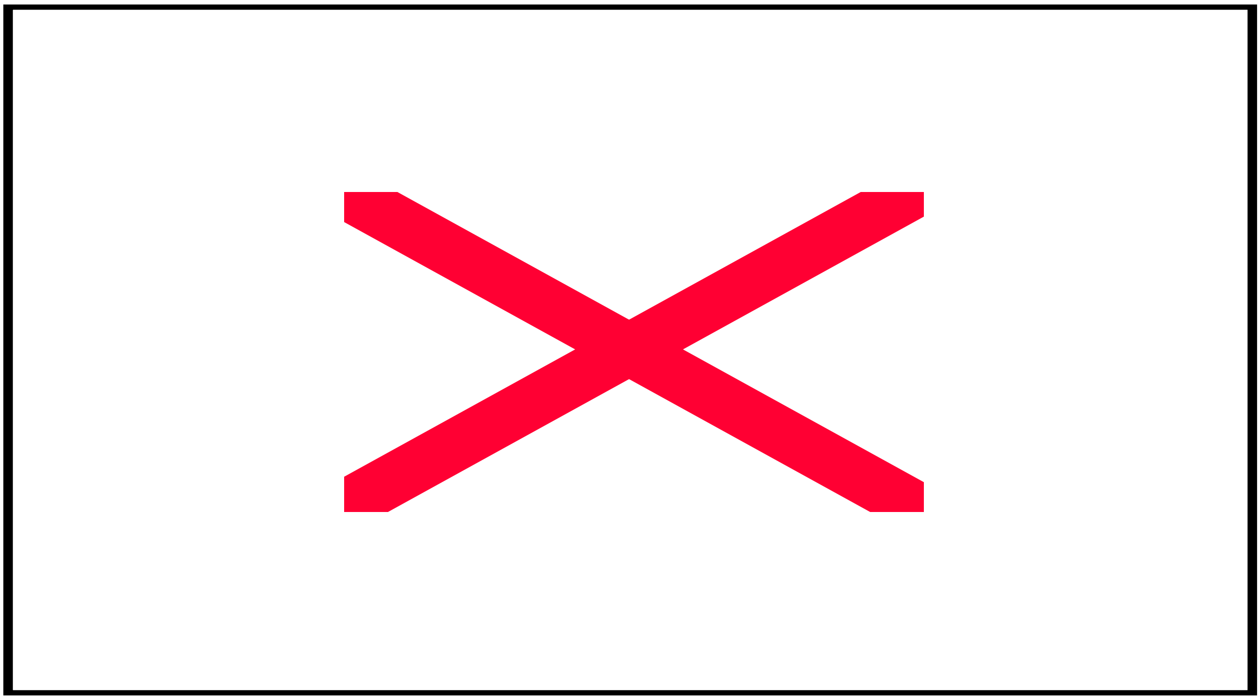

Figure 2: Data in- and output of the mass flow optimisation model ARGUS

Similar to PERSEUS, the production and abatement techniques applicable to representative “reference installations” [9, 10] of a sector are described by technical, economic and environmental parameters. In addition to the technical and environmental characterisation in the mass flow model, a capacity can be assigned to each considered production process and implemented abatement technique.

The target function for optimisation is to minimise the sum of the discounted expenditures (using the net present value method) associated with the different time periods within a given planning horizon (see 2.1). This is done by taking into account the achievement of the emission reduction targets and the demand scenarios specified exogenously. The optimisation variables are the implementation shares of the different emission reduction options. The evolution of sectoral activities and market shares of reference installations are specified exogenously.

The represented industrial sectors can be linked by the introduction of a supra-sectoral emission restriction in a country specific way in order to establish a national or regional model.

The mass flow model ARGUS is implemented on PC, using also the algebraic modelling language GAMS. The model provides an adaptable user interface for the input and modification of techno-economic data. The results of the optimisation are presented in an aggregated and transparent way as a report and can be further processed within MS-Excel.

The mass flow model ARGUS has been used in the framework of UN/ECE protocol negotiations. Furthermore, it is applied currently for France to assess the costs of an emission reduction induced by the implementation of the EU Solvent Directive and to investigate the feasibility of regional air quality management plans for VOC.

3. Methodological aspects

3.1 Dynamic aspects in energy and material flow models

Within the models, it is possible to represent dynamic effects such as the variation of the demand or the structural change (renewal of installations) within a sector. Since within the sectoral mass flow models PERSEUS and ARGUS, several periods are considered, an intertemporal allocation of the positive variables (capacities and flows) is made possible. Thus, a quasi-dynamic optimisation can be realised. By considering the structural change, the existing installations with their respective technical lifetime are represented. By means of a lifetime model which is linked to the mass flow model ARGUS, the remaining share of a given baseline population of installations for future periods is calculated and integrated in the mass flow model by the formulation of respective minimal capacities in future periods as a boundary condition. A further dynamic aspect of the presented methodology is realised by discounting all expenditures to the base year within the target function. Here, the net present value method as a dynamic investment calculation procedure is applied.

3.2 Interdependencies and combined emission reduction strategies

Due to the fact that there are strong interdependencies between different abatement measures, the elaboration of cost functions is not trivial. For example, the effectiveness of energy saving measures on the demand side depends on the current energy prices. However, these prices are influenced by the implementation or non-implementation of expensive abatement measures on the energy supply side. Due to such interdependencies it is not possible to simply add the reduction potentials and costs of the various options to develop a cost-effective and consistent mitigation strategy. For the development of strategies regarding all options simultaneously and taking into consideration the interdependencies between the options, models which are able to take into account all possible options simultaneously have to be used.

Interdependencies also need to be considered with regard to combined emission reduction strategies due to the fact that the majority of reduction options for a specific emission have positive or negative effects on the development of several other emissions (see chapter 4).

3.3 Handling of uncertainties

Up to now, the models of the PERSEUS family as well as ARGUS have been based on a deterministic approach, risk regarding the future development of relevant input parameters could only be considered by evaluating different scenarios. With alternative economic framework assumptions - e. g. with regard to the development of prices for primary energy carriers - having a substantial impact on the results, different assumptions have been considered using this scenario approach.

In order to be able to adequately consider the growing uncertainties in liberalised energy markets, the PERSEUS model has been enhanced by integrating stochastic programming techniques. Depending on the question at hand, stochastic programming methods with or without recourse (see, e. g., [8]) can be used.

Using linear stochastic programming without recourse, risk for all parameters of a model can be described by expected value and a variance measure, e. g. standard error if a normal distribution is assumed for the risky parameters. However, due to the effort inherent in the determination of valid assumptions regarding the distribution of input parameters, risk should only be considered for selected parameters of particular relevance for the model results.

Stochastic programming with recourse is especially useful for determining hedging strategies against the occurrence of events changing the planning framework. For instance, the outcome of the current discussion on a limitation of the lifetime of nuclear power plants in Germany is of critical importance for the planning of replacement investments. By assigning probabilities to possible scenarios for the shut-down of nuclear power plants, a strategy which is not necessarily "optimal" for any specific case, but which can be adjusted to different outcomes of the political discussion without sacrificing competitiveness can be elaborated.

4. Results concerning impacts of a CO2 reduction on SO2 reduction strategies

Several studies based on energy and material flow optimisation models have shown the significant influence of greenhouse gas emission reduction on the structure of the energy system and on the reduction of emissions of pollutants, in particular SO_2. In the following, some selected results of the PERSEUS model regarding combined emission reduction strategies for the Federal Republic of Germany will be presented.

In a cost optimal strategy for a reduction of SO_2 emissions, end-of-pipe technologies are the dominant emission reduction measure, leading to an increase of CO_2 emissions (due to a decrease of the efficiency of power plants equipped with end-of-pipe technologies). Only ambitious SO_2 reduction goals, which can only be realised by fuel substitution and efficiency improvements, can have a positive influence on the development of CO_2 emissions.

On the other hand, one of the most important measures for a cost effective reduction of CO_2 emissions is the substitution of coal and oil by natural gas, which leads also to a significant decrease of SO_2 emissions. Further relevant CO_2 emission reduction options, such as the improvement of efficiencies in the energy conversion sector and the installation of energy conservation technologies in the energy demand sectors also have a positive effect on CO_2 as well as on SO_2 emission development. Therefore, strategies for the protection of the climate lead to a considerable reduction of SO_2 emissions. Model analyses show that a 10 percent reduction target for the CO_2 emission in the year 2010 – based on the emissions of the reference case without CO_2 emission reduction goal in the year 2010[8] – avoid almost 50 kt of SO_2 emissions (compared to the reference

[8] In this reference case, the level of CO_2 emissions in 2010 is 871 Mio. t.

case which includes the installed SO_2 and NO_x emission reduction measures in Germany).

For a CO_2 reduction goal of 15 percent (or 20 percent), this amount increases to 110 kt SO_2 (or 150 kt SO_2). For a 25 percent reduction target – this corresponds to a reduction of 36 percent relative to the base year 1990, the reference year in the UN Framework Convention on Climate Change – it is possible to avoid almost 170 kt of sulphur dioxide emissions.

An additional analysis referring to the CO_2 reduction target of the government of the Federal Republic of Germany - reduction of CO_2-emissions by 25 percent in the year 2005, relative to the emissions of the year 1990 – shows that in this case it is possible to simultaneously reduce SO_2-emissions by about 100 kt.

The results show the meaning of simultaneous emission reduction strategies even in countries such as the Federal Republic of Germany which have already realised ambitious emission reduction targets for SO_2 and NO_x emissions.

5 Results concerning the impacts of structural changes on VOC reduction strategies

The ARGUS model has been used in the framework of UN/ECE protocol negotiations and it is currently applied for France to assess the costs of an emission reduction induced by the implementation of the EU Solvent Directive [13/99/EC] as well as to investigate the feasibility of regional air quality management plans for VOC.

The ARGUS model allows to determine emissions for the base year (1995) and their evolution until the target year of the protocol (2015) and to elaborate cost functions on the sectoral and national level, considering different scenarios reflecting different periods and pathways for the implementation of the emission reduction targets.

Especially the dependency of the shape[9] and the level of the resulting cost functions on the parameters within the model are analysed. The modified parameters in this context are:

1. variation of transition periods for the achievement of the emission target,
2. extension or reduction of the planning period,
3. variation of the calculation interest rates within the calculation of cost functions.

The mass-flow optimisation model ARGUS-VOC is composed out of individual mass flow models for about 40 emission relevant sectors. For the establishment of a national mass flow model for Germany [10] and for France [11] and for the verification of the input data and of the applied methodology, cost functions for each individual sector have been elaborated. Figure 3 exemplarily shows the calculated baseline emission trend for Germany for the period from 1995 to 2010 and the cost functions for VOC emission sources from stationary sources in Germany [10]. The different cost functions are

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[9] Which means base emissions, maximum feasible emission reduction, emission reduction potential, development of the increase of the marginal costs, etc.

calculated for different implementation scenarios (short and long term transition period, linear emission reduction pathway) for a variation of the duration of the considered planning period and for a variation of the applied calculation interest rates. Regarding the cost function for different implementation scenarios, the costs expressed in annuities strongly decrease and the maximum feasible emission reduction increases when transition periods for the achievement of the assumed emission reduction target are increased from the year 2000 (short-term scenario) to 2015 (long-term scenario). This difference is mainly due to the influence of considered structural options whose potentials strongly increase with the delay for the achievement of envisaged emission reduction targets. The realised studies further show that the chosen interest rate and the state of implementation of emission reduction options in the base year have an important influence on the cost functions. Similar results have been obtained for France [11].

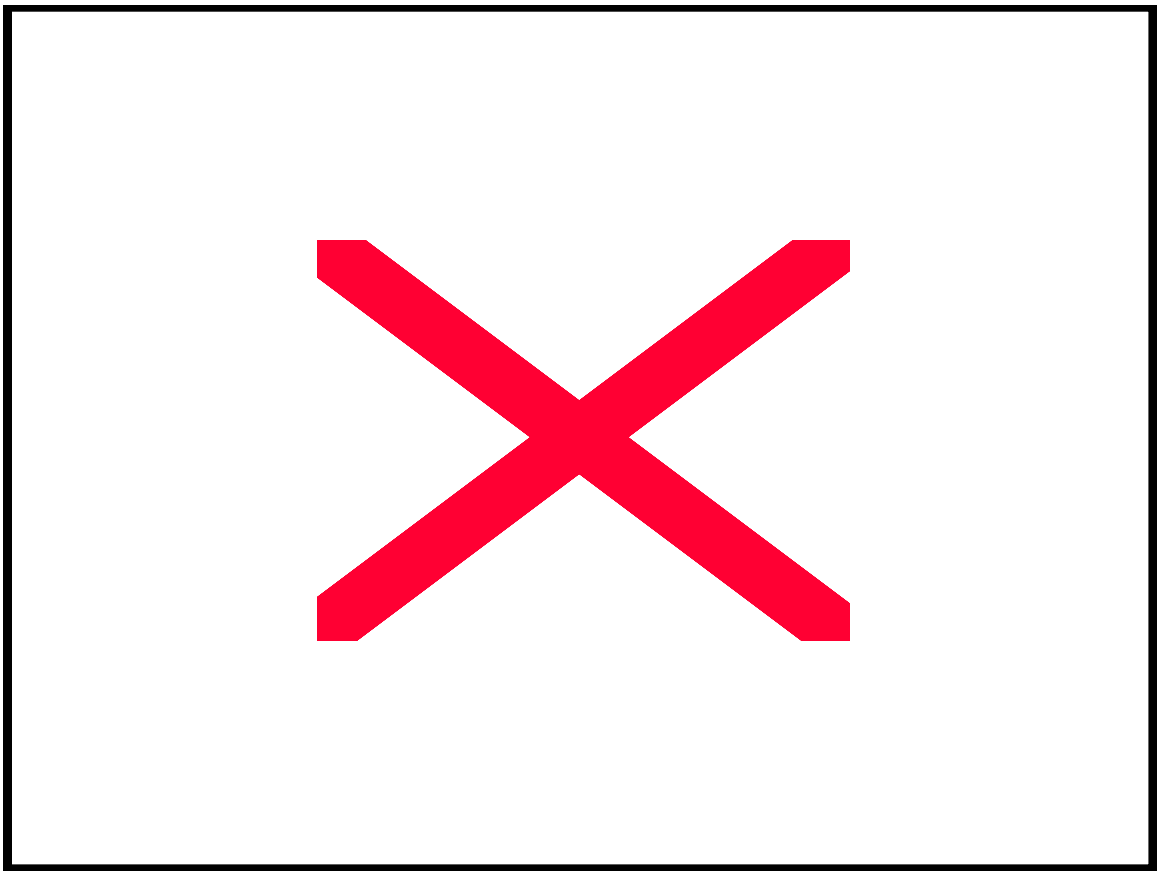

Figure 3: Calculated baseline emission trend for Germany from 1995 to 2010. Cost functions for VOC emission sources from stationary sources in Germany for the different implementation scenarios, for a variation of the duration of the considered planning period and for a variation of the applied calculation interest rates. [10]

6 Conclusions and recommendations

Optimising energy and material flow models such as PERSEUS and ARGUS are adequate tools for the development of national cost curves since they can handle important methodological requirements like uncertainties, dynamic aspects, combined control strategies and interdependencies between reduction options. Furthermore, the user-friendliness of the models has been vastly improved in the last few years.

The models have been widely used in the past as decision support tools on several levels of national and international activities. The model results confirm that for the future update of the Protocols under the Convention on Long-Range Transboundary Air Pollution – but also for the analysis of the impacts of environmental legislation - the following aspects affecting the development of national emission reduction cost curves have to be considered:

- combined emission reduction strategies (including CO_2-emission reduction),
- the restructuring of the industrial sector (fuel and material switch as well as technology substitution),
- the transition periods for the achievement of the emission reduction targets and
- the interdependencies within and between the sectors.

Due to the importance of national cost functions for the multi-national allocation of emission reductions and to guarantee a consistent set of results for all Parties to the Convention over time,

- in the future a consistent and transparent set of national technology data bases is necessary as an input for the calculation of national cost curves,
- a harmonised development and application of adequate methods for the development of national cost functions is desirable and
- a transparent process for the verification of the country cost curves by national experts have to be designed.

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Annex A Agenda

Workshop on Future Needs for Regional Air Pollution Strategies

10-12 April 2000 Saltsjöbaden,
Sweden

Monday 10 April

11.30 Lunch (optional)

Plenary session 1 Chairman *Lars Lindau*, *Swedish Environmental Protection Agency*

13.00 Opening. *Måns Lönnroth, Executive Director, MISTRA*

13.15 Practical information

13.20 The experiences of regional air pollution strategies and prospects for the future.
- CLRTAP: *Lars Björkbom*
- North America: *William Harnett, US EPA*
- EU: *Martin Lutz, DG Environment, European Commission*

14.50 Coffee

15.15 Future development and possibilities

- Driving effects and critical loads. *Keith Bull, UN ECE, CLRTAP Secretariate*

- Transboundary fluxes. *Anton Eliassen, Norwegian Meteorological Institute*

- Scientific challenges. *Peringe Grennfelt, Swedish Environmental Research Institute*

16.45 Refreshments

17.00 Tools for cost effective control strategies. *Marcus Amann, IIASA*

17.30 Future emission control within the transportation sector -new technologies or structural changes? *Thomas Verheye, European Commission*

18.00 Formation of working groups

19.30 Dinner at Grand Hotel Saltsjöbaden. Hosted by the Nordic Council of Ministers and the ASTA research programme

Tuesday 11 April

09.00 Working Groups: Session 1

10.30 Coffee

13.00 Lunch

14.00 Working Groups: Session 2

15.30 Coffee

20.00 Dinner

Wednesday 12 April

08.30 Working Groups (opotional). Preparation of workshop report.

09.30 Coffee

Plenary session 2 Chairman *Anton Eliassen*

10.00 Reports from the working groups

12.00 Lunch

13.30 Conclusions from the workshop Chairman *Lars Nordberg*

15.00 Closing of the workshop *Jan Thompson*

Annex B List of Participants

Annex C Abbreviations

AMAP	Arctic Monitoring and Assessment Programme
ASTA	The Swedish research programme International and National Abatement Strategies on Transboundary Air Pollution
CAFE	Clean Air For Europe. An EC DG ENV initiative to support air pollution control strategies and legislation.
CLRTAP	UN ECE Convention on Long-range Transboundary Air Pollution
DG ENV	European Commission DG Environment
EB	Executive Body of the CLRTAP
EC	European Commission
EEA	European Environment Agency
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollution in Europe. A subsidiary body under the CLRTAP.
EUROTRAC	European Experiment on the Transport and Transformation of Environmentally Relevant Trace Constituents in the Troposphere over Europe
FCCC	Framework Convention Climate on Climate Change
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organisation
TFIAM	Task Force on Integrated Assessment Modelling
NGO	Non-Governmental Organisations
POPs	Persistent Organic Compounds
UN ECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
WGE	Working Group on Effects. Subsidiary body under the CLRTAP
WGSR	Working Group on Strategies and Review. Subsidiary body under the CLRTAP
WHO	World Health Organisation
WMO	World Meteorological Organisation
VOCs	Volatile Organic Compounds

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